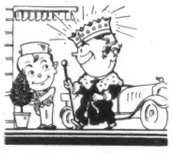
The EDITOR'S PAGE

Heating · Piping *and* Air Conditioning

Skilled in the art of giving its patrons what they want, the management of the Occidental Hotel in Washington, D. C., installed an air-conditioning system for its dining rooms a few weeks ago. Clifford F. Holske's article on page 538 of this issue describes this system—which is ice-cooled—showing how the necessary equipment is arranged and giving



a tabulation of the cooling load, amounts of ice delivered, etc., and the results of a test run to find the conditions maintained.

Numerous autographed photographs of distinguished patrons—presidents, supreme court justices, congressmen, kings, princes, and others—indicate the regard in which the Occidental's cuisine is held. Many restaurants consider properly conditioned air just as important as good food in pleasing its patrons—and in operating profitably.

F. E. Wertheim's discussion of high-pressure leak-tight joints on page 546 contains an explanation of the new "unsupported area principle" developed and used by Dr. Percy W. Bridgman in his work with pressures of 550,000 lb. per sq. in.—a bit higher than we'll have to worry about for some time, perhaps, but of particular interest because of possible industrial applications of his method of holding this pressure. The article also describes several other joints which have successfully met various service conditions.

As evidenced by the wide range of materials handled in piping systems, piping engineering is a field in itself. The piping in every plant represents an important part of the mechanical equipment, and its correct design, installation, operation and maintenance is an essential to the proper and economical functioning of the plant.

Handling hot water is always a problem, particularly from a corrosion standpoint. In the lead-off article this month, C. E. Joos and V. A. Rohlin devote themselves to the important topic of combating corrosion of piping. This month's installment explains the why of corrosion and shows how "pH value" indicates the corrosiveness of a water. In a succeeding article by these same authors, preventive measures will be discussed.

COMING!

Don't miss these articles to appear in early issues.

Walter L. Fleisher's paper on drying leather and similar materials

•

T. S. Tenney's article on heating a skyscraper with hot water

•

Electric arc welding a process-steam line, by H. C. Schramm—for steam at 600-lb. pressure and 720 degrees

•

William L. Hand tells how rolling and turning of pipe being welded was prevented by the contractors installing the all-welded heating system for the new Field office building in Chicago's financial district in the article starting on page 541. When finished, this development will be the fourth largest office structure in the world, it is said.

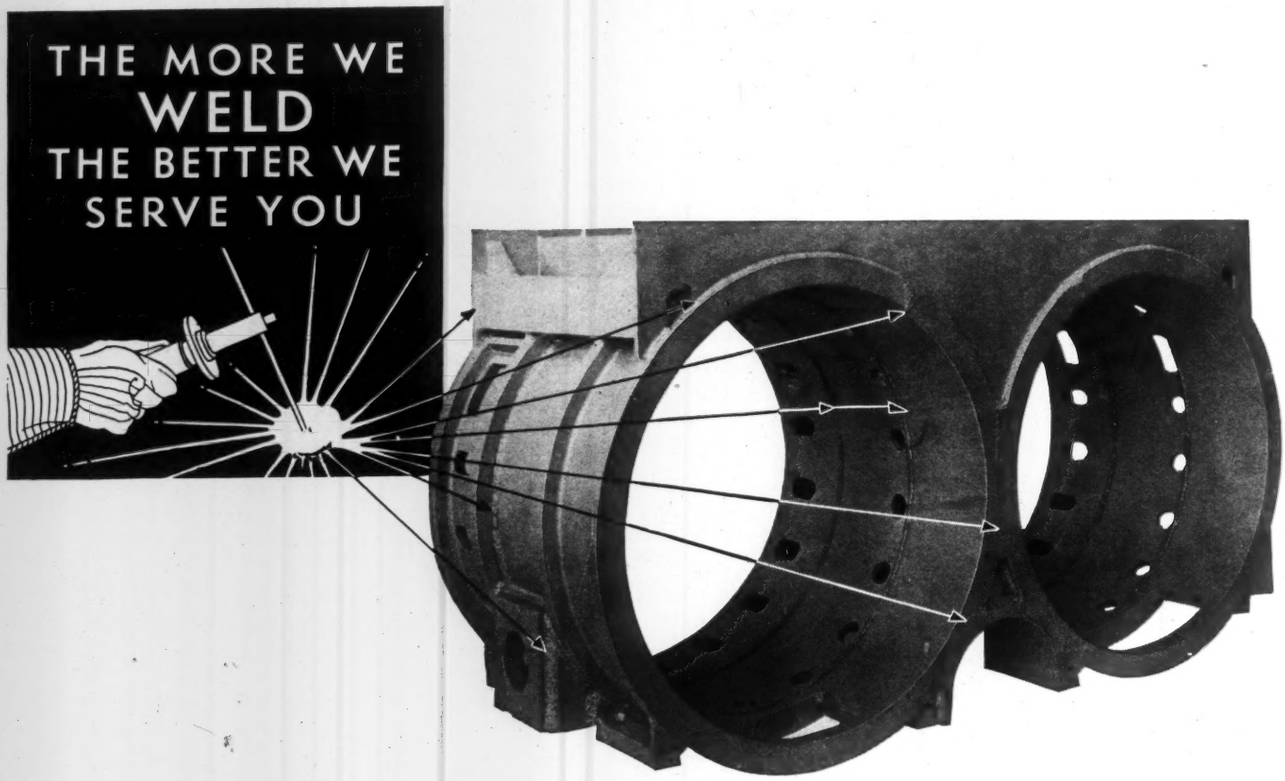
Installing a heating system in a modern skyscraper requires well-organized plans as the piping must go up with the building at all times. Risers were delivered in random lengths with bevelled ends ready for welding; radiator branch pipes were delivered properly bent for installation.

Not only is ceiling drip in high-humidity rooms a nuisance but it leads to rusty machinery, damaged goods, unhealthful or dangerous working conditions; roof insulation is often the answer.

The article on page 543 of this issue describes the experiences of two typical plants with roof condensation and drip and tells how they stopped the trouble. A chart for figuring the proper thickness of corkboard insulation—one material that is used widely for this purpose—appears with the article.

"Piping Steam for Heating Oil Tanks," in which Samuel R. Lewis shows effective piping layouts for heating oil, will appear next month instead of this, as previously announced.

In planning the air-conditioning system for the Times-Mirror Printing and Binding House benefits—not cost—were the qualifying conditions, as described by E. L. Ellingwood on page 550.



208 Feet of Arc Welding in this one motor

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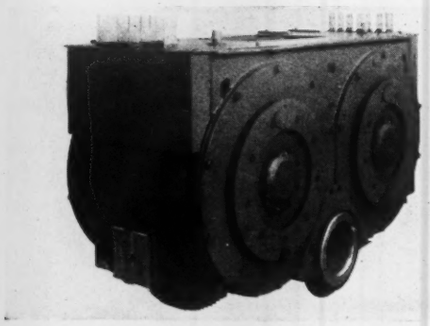

The result—a simpler and less costly design; and new trails blazed in arc-welded fabrication.

If it's a problem in arc welding, get in touch with G-E Welding Service at your nearest G-E office. There, your welding problems can usually be solved by the aid of data already on file; and there all the arc-welding equipment you possibly need can be obtained on one order blank from one dependable manufacturer.

530-129

GENERAL ELECTRIC

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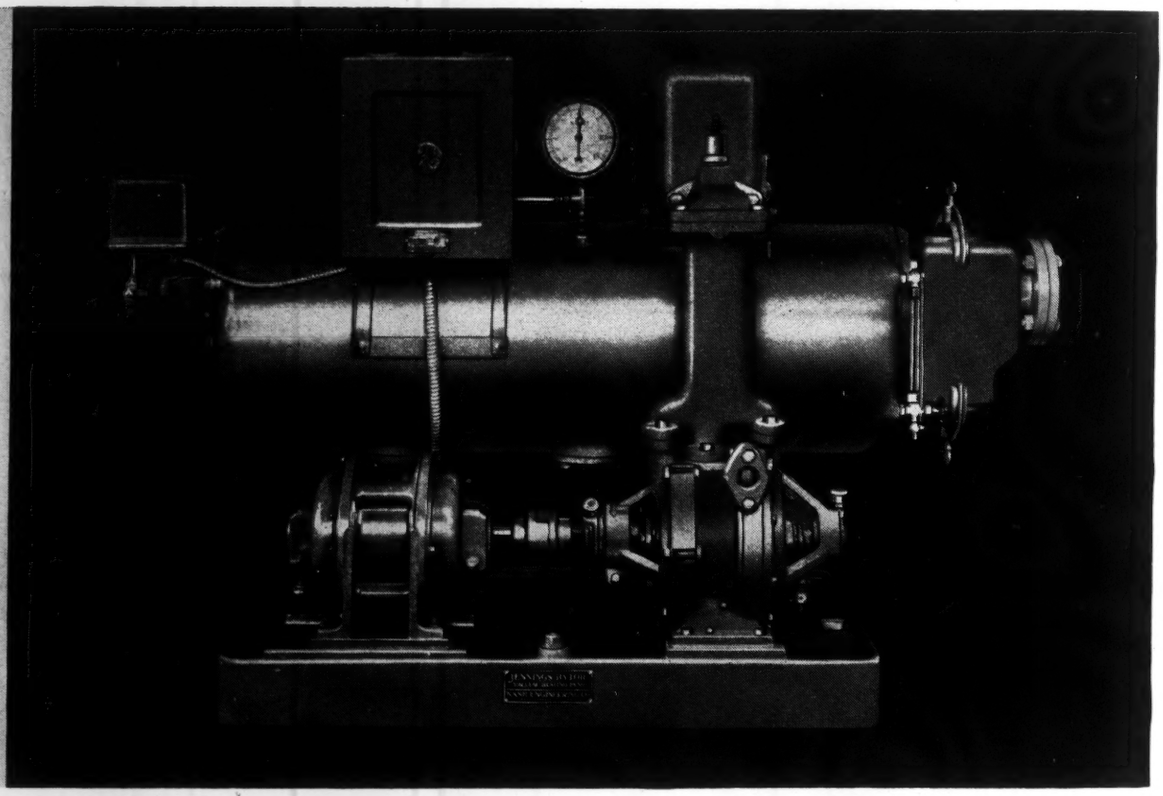

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Heating · Piping and Air Conditioning

Vol. IV August, 1932 No. 8

Combating Corrosion of Piping

By C. E. Joos* and V. A. Rohlin†

LOSS of capacity due to choking by rust, and failure of piping caused by corrosion, necessitating extensive replacements, are receiving increasing attention with the present stress on economy in the industrial and commercial fields. The presence of rust in water causing "red water" is also disagreeable and a nuisance. Even where corrosion does not ruin piping deposition of rust greatly reduces the carrying capacity. In a paper entitled "Causes and Correction of Red Water," Thorndike Saville states, ". . . one may say that when one twenty-seventh of the thickness of the wall of a ½-in. iron pipe, or one-fortieth of the thickness of a 1-in. iron pipe is corroded, the pipe is completely choked up." Therefore, if it were not necessary to prevent corrosion for any other reason, preservation of the carrying capacity of the pipes alone would make the finding of a remedy desirable.

To combat corrosion numerous preventative measures have been proposed and are available, including the use of corrosion-resistant materials, chemical treatment of the water, and the removal of dissolved gases by heat. The choice of protective equipment or corrosion-resistant materials should be determined by the circumstances of the individual plant. This paper deals principally with treatment of the water supply to prevent corrosion of water lines, such as boiler feed and hot-water distributing and service piping and of economizers in boilers.

To obtain a clear conception of the problem and to be able to select intelligently the method which is most practical and economical, it is first necessary to study the causes of corrosion.

*Chemical Engineer, Cochrane Corporation, Philadelphia, Pa.
†Chief Engineer, Cochrane Corporation, Philadelphia, Pa.

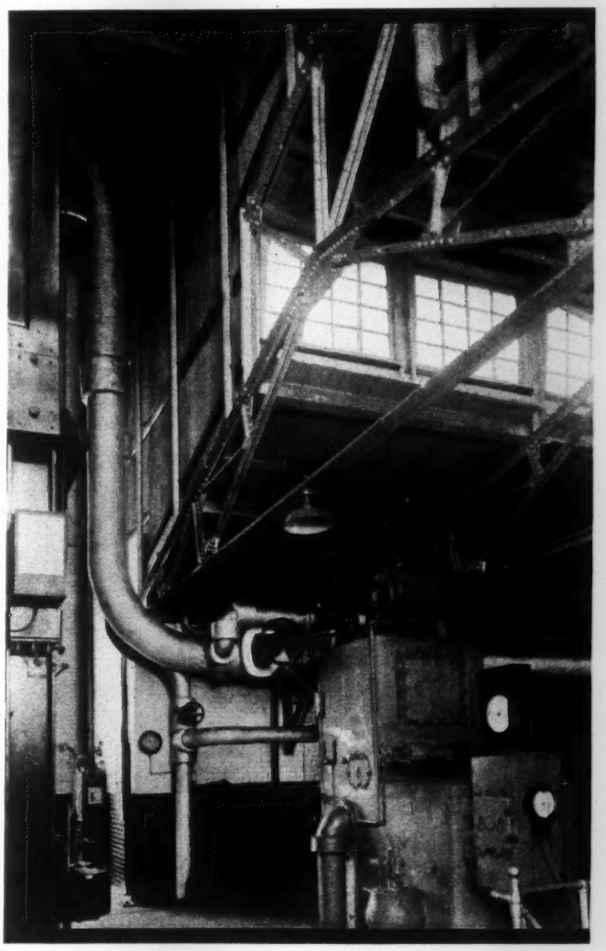


FIG. 1 — DEAERATING HEATER HAVING A CAPACITY OF 136,000 LB. PER HOUR AT THE CRYSTAL SPRINGS BLEACHERY, CHICKAMAUGA, GA. THE WATER IS USED FOR GENERAL SERVICE AND BOILER FEED, FIRST BEING SOFTENED IN A WATER SOFTENER

Causes of Corrosion

The major causes of corrosion, whether of iron, steel, brass, copper or lead, are

a Active acidity indicated by low *pH* value
b Oxygen in solution
c Electrolysis

The most common cases of corrosion can be accounted for by *a* and *b*, usually in combination.

What "pH" Means

Briefly, the *pH* value is a numerical index of the degree of active acidity or alkalinity, as contrasted with total acidity or alkalinity as determined by titration methods. For an explanation of the meaning of *pH* value one must turn to the causes of acidity and alkalinity. Pure distilled water is composed of molecules expressed as H_2O or HOH and also of the same molecules dissociated into hydrogen and hydroxyl ions expressed as H^+ and OH^- respectively. The exponents represent electrical charges, positive and negative. Now, just as the ions are formed as the result of the splitting up of the molecules, molecules will form as the result of the combination of ions, as represented by the formula

$$H_2O \rightleftharpoons H^+ + OH^-$$

The process of splitting and recombination continues but reaches an equilibrium where the splitting and recombination are exactly equal, so that the total number of ions and the total number of molecules remain constant respectively.

The *pH* value is an index of the fraction of the hydrogen present that is ionized. In pure distilled water the fraction is $1/10^7$ or 10^{-7} and an equal number of hydroxyl ions will also be present. In any aqueous solution the product of the fraction of the ionized hydrogen times the fraction of the ionized hydroxyl is a constant and equal to 10^{-14}. If the solution is acid the ionized hydrogen is represented by a fraction greater than $1/10^7$ and the ionized hydroxyl by a lesser value. In that case the exponent in the denominator of the hydrogen ions fraction would be less than 7, as, for example, 6, so that the exponent in the denominator of the hydroxyl fraction would be 8.

The exponent in the hydrogen fraction is used as an index of acidity and is known as the *pH value*. If the *pH* value be less than 7 the solution is acid, but if greater than 7 it is alkaline. If the concentration of hydrogen ions be represented by *pH—6*, it is equal to $1/10^6$, which is ten times as great as $1/10^7$, or *pH—7*. A water of *pH—5* would therefore contain 1,000 times as many hydrogen ions and 1/1000 as many hydroxyl ions as a water of *pH—8*. Consequently, as any degree of active acidity or alkalinity may be expressed by the hydrogen-ion concentration alone, it is not necessary to designate active alkalinity by hydroxyl concentration, but the degree of hydrogen-ion concentration can be used to express either. It is only necessary to remember that a neutral aqueous solution has a *pH* value of 7.0, and that an acid solution has a *pH* value of less than 7.0, and that an alkaline solution has a *pH* value greater than 7.0.

Corrosion—arch-enemy of the engineer—costs industrial buildings, office buildings, schools, hospitals, hotels and other types of structures thousands of dollars every year. Prevention of corrosion, particularly in piping systems, is eminently worthwhile from an economical standpoint. Through proper selection of materials, design of systems, installation and maintenance and methods of treating water supplies, important savings can be made. This article explains the causes of corrosion, takes the mystery out of "pH value"; other articles in this series will tell how corrective measures may be made.

pH Value Indication of Tendency Toward Corrosion

Since the *pH* value is a measure of the active acidity or alkalinity of a solution, it can be used to predict a tendency toward corrosion. Total acidity as determined by titration is a measure of the number of hydrogen ions which are available for certain chemical combinations and does not measure the activity or aggressiveness of an aqueous solution. For example, concentrated sulphuric acid is only very slightly ionized and can therefore be shipped in steel tank cars, whereas dilute sulphuric acid having a strength of only 5 or 10 per cent and which is highly ionized, is very destructive. As a matter of fact, concentrated sulphuric acid sufficiently titrated with sodium hydroxide would become highly corrosive.

As applied to corrosion, for example, the *pH* value controls the intensity of the corrosive action, while the total acidity is a measure of the amount of corrosion that will occur before the acid is exhausted.

Controlling Effect of pH Value Explained

To understand the controlling effect of *pH* values on the corrosion of metals, it is necessary to consider the method by which such metals enter solution and the factors governing their solution rate.

Most everyone is familiar with the experiment of copper plating iron by immersion in a solution of copper sulphate. Here the iron enters solution as the ion and the copper is plated out as the metal:

$$Fe + Cu^{++}SO_4 \longrightarrow Fe^{++}SO_4^{=} + Cu$$

Thus an exchange of metals takes place with the iron being taken into solution. The ability of one metal to displace another, or be displaced by it, is dependent upon their relative positions in the electromotive series. Of the common metals used, this order may be listed as follows:

Aluminum	Nickel
Zinc	Tin
Chromium	Lead
Iron	Copper

in which each metal has a greater electric potential than those following it, and will displace them from solution. The intensity of displacement decreases as we go down the list. All of the metals except copper will displace hydrogen with the same order of diminishing intensity. Hydrogen is located in this series between lead and copper. Thus when iron is in contact with water, iron enters solution while the hydrogen is plated out:

$$Fe + 2H^{+} \longrightarrow Fe^{++} + H_2$$

Iron + Hydrogen Ions → Iron Ions + Hydrogen Gas

Just as long as there are sufficient hydrogen ions in solution the displacement will continue. If, however, the concentration of hydrogen ions is reduced, as by the introduction of caustic soda, the rate of displacement will be reduced and, conversely, if the hydrogen-ion concentration is increased by the introduction of an acid, the rate of displacement is increased. Thus the hydrogen-ion concentration determines the rate at which any given metal will enter solution. If it is sufficiently reduced—the *pH* value sufficiently increased—the rate of displacement will be negligible. Fig. 2 illustrates the relation between the *pH* value of the water solution and the evolution of hydrogen gas or, in other words, the rate of solution of iron.

Reducing Available Supply of Ionic Hydrogen Lowers Corrosion Rate

It has been seen that iron, upon entering solution, takes on the electrical charge of the hydrogen ions, and only after it is so charged can it combine with the *OH* ions to form $Fe(OH)_2$. Thus its ability to enter solution is governed by the ability of the aqueous solution to supply, in the form of *H* ions, the charge required.

As hydrogen gas is evolved as fast as this exchange of electrical charges takes place, it follows that any condition tending to repress the evolution of hydrogen gas or reduce the available supply of ionic hydrogen will tend to arrest the flow of iron into solution—thus to lower the corrosion rate. In a quiet solution, in the absence of oxygen, the removal of the *H* ions is accompanied by a proportionate increase in the concentration of the *OH* ions, the numerical product of the concentrations $(OH \times H)$ remaining constant. Ultimately the number of *H* ions in the solution will be so reduced that the process of plating them out will discontinue and corrosion will stop. Also, since iron enters solution as $Fe(OH)_2$, this process cannot continue further than to the limit of saturation of $Fe(OH)_2$.

The rate of solution of iron in water of varying *pH* values may be compared with the rate at which sodium chloride or any other soluble salt will enter solutions of different concentrations of the same salt. Thus if we start with distilled water and maintain a definite temperature and add salt to it in equal portions at a time, we know that the first addition goes into solution very rapidly, whereas it takes longer to dissolve each succeeding portion as we approach the saturation point. The last portion added before saturation is reached goes into solution with difficulty and very slowly as compared to the first portion. Any further addition of salt beyond the saturation point refuses to go into solution and will remain as the solid.

If to the satured salt solution we add hydrochloric acid it will be noted that some of the salt will precipitate and further additions will cause more precipitation until if enough hydrochloric acid is added the amount of salt remaining in solution will be very slight as compared to the original saturated solution. The solubility of the *NaCl* is therefore affected by the concentration of the chlorine ion *Cl*.

The ability of the sodium to remain in solution has been reduced by the excess of chlorine from the acid, because in common with all other ionized solutions the product of the two ions (in this case of *Na* and *Cl*) cannot be increased. The same experiment may be carried out by substitution of any chloride more soluble than salt, such as calcium chloride ($CaCl_2$).

If we carry our experiment further by using solid sticks or lumps of salt and immerse some in glasses of distilled water and others in solutions containing chloride of increasing concentrations, for instance, increasing the chloride content by using calcium chloride until the last solution contains an amount of chloride (*Cl*) corresponding to the amount of *Cl* present in a saturated salt (*NaCl*) solution, we will find that the rate and amount of salt dissolving will be greatest with distilled water diminishing as we approach the last glass, which will be unaffected. **The important consideration in these examples is the fact that the solubility of a substance is affected by the concentration of either of its ions.**

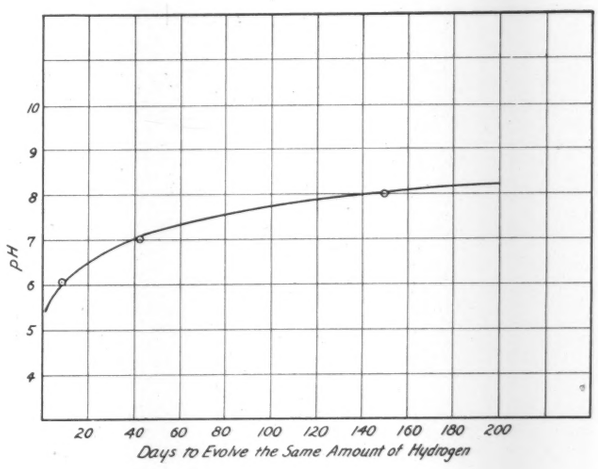


FIG. 2—RATE OF DISPLACEMENT OF HYDROGEN BY IRON FROM WATERS OF VARYING pH VALUES

Reproduced from "Canadian Chemistry and Metallurgy," pp. 121-124, 1924, J. W. Shipley and I. R. McHaffie.

In the case of the iron, it must be remembered that it too enters solution only as the compound $Fe(OH)_2$, and the total amount contained in a saturated solution can also be controlled, as in the preceding examples, by varying the *OH* content of the solution—by controlling the *pH* value. If we increase the *pH* value, (increase *OH* ions) as by introduction of caustic soda *NaOH* to a point corresponding to a saturated solution of $Fe(OH)_2$ at the temperature of the water, we will prevent any iron from entering the solution and con-

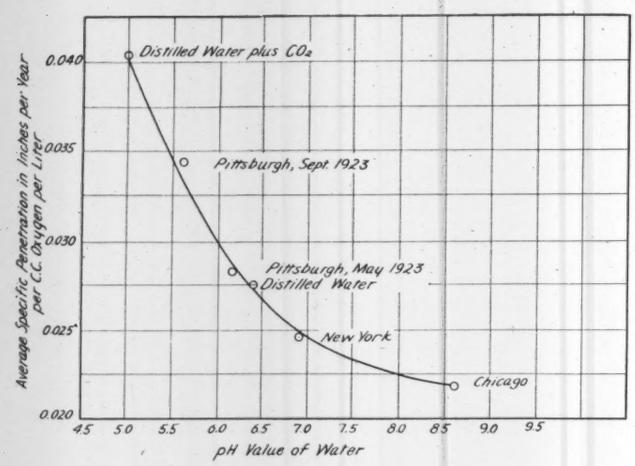


FIG. 3—EFFECT OF pH VALUE ON CORROSIVENESS OF SEVERAL WATERS ON BASIS OF EQUAL OXYGEN CONTENT

Reproduced from "Corrosion" by F. N. Speller, p. 340, McGraw-Hill Book Company, Inc., 1926.

sequently prevent corrosion regardless of the oxygen concentration. Thus the solution of iron in water is similar to the solution of salt in solutions of varying chloride content if we consider the concentration of OH ions to correspond to the Cl ions in the previous example of common salt entering solution. The comparative example is drawn because we do not ordinarily think of iron or other metals as being a soluble substance. Yet all are soluble to a limited extent and the order of solubilities is the same as the order of the electromotive series, the solubilities diminishing as we go down the list. The practical demonstration of the effect of pH values on the corrosiveness of various water supplies is pictured in Fig. 3.

Oxygen in Solution Is Part of Corrosion Picture

If the entire corrosion picture were illustrated by the above reactions and limited to the formation of $Fe(OH)_2$, we would have no red water problem. However, $Fe(OH)_2$ combines very readily with oxygen in water solution to produce ferric hydrate, or what is commonly called rust:

$$2Fe(OH)_2 + O + H_2O \longrightarrow 2Fe(OH)_3.$$

The $Fe(OH)_3$ is relatively insoluble and its precipitation removes the OH from solution. Thus the H ion concentration is not repressed as would be the case of the OH remaining in solution as the result of the plating out of hydrogen, and the solution continues just as rapidly as the oxygen removes the OH ions.

The entire process of iron entering solution and thence being oxidized by the oxygen in solution is very ingeniously demonstrated by Nelson[1]. A test tube is half-filled with boiled (deaerated) water, into which is placed a bright iron nail. A band of paper pulp or cotton is placed on the surface of the water and the remainder of the tube is filled with deaerated water. After a sufficient lapse of time it will be noted that the band will take on a rusty color (Fig. 4), while the solution below the band remains clear and the nail bright. This demonstrates that the iron first enters solution and that the combination with oxygen, to form rust, is a secondary process. The solution of $Fe(OH)_2$ has permeated the cotton or paper pulp band and the oxygen of the air gradually penetrating the upper strata of water has oxidized the $Fe(OH)_2$ at the band before reaching the solution below it. If the test were continued the oxygen would penetrate to the lower part of the tube and there deposit rust, as well as on the nail. The corrosion would not be limited because the $Fe(OH)_2$ would be removed from solution by combination with oxygen and this would not concentrate to build up the pH value.

If we carry Nelson's experiment further by sealing the tube with a limited supply of oxygen the corrosion would also be limited and the solution of the iron stopped when the solubility of $Fe(OH)_2$ had reached the saturation point, after the oxygen had been removed by combination.

If, instead of using deaerated water in the tube, we substitute tap water saturated with oxygen, and increase the pH value to that produced by the ferrous hydrate by the introduction of caustic soda, no solution of iron will take place and, consequently, no red band of iron oxide will appear, for oxygen will only attack iron in solution except, of course, at elevated temperatures, which is beyond the scope of this paper. In the corrosion of hot-water pipe lines the flow of water does not allow for this natural building up of pH value due to ferrous hydrate, as the hydrogen-ion concentration is maintained by the continual replacement of water due to flow past any given point, and the rate of solution varies with the pH value of the water—the lower the pH value the higher the rate of dissolution. The supply of oxygen is also replenished by the flow of water.

An example of restricted oxygen content, and therefore restricted corrosion, is a hot-water heating system. Here the water is continually recirculated, and once the initial oxygen has been spent there is no opportunity for replenishment except, of course, through make-up to replace any leakage in the system. The natural build-

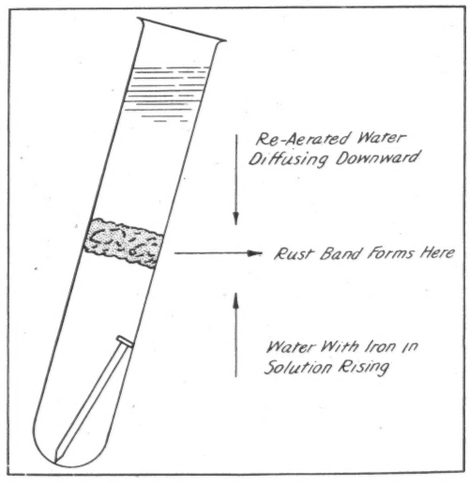


FIG. 4—ILLUSTRATING SOLUTION OF IRON IN WATER AND SUBSEQUENT FORMATION OF RUST DUE TO OXYGEN AS SECONDARY REACTION

[1] Heat and Corrosion Resistant Alloys, T. Holland Nelson Vd. XIVIII No. 12, Dec., 1931, *Engineers & Engineering* (Phila. Engrs. Club).

ing up of the *pH* value is allowed to proceed due to saturation with $Fe(OH)_2$ and thus solution of the iron is arrested. Hot-water service lines are examples of unrestricted corrosion where the *pH* value is low.

An inspection of the electromotive series of metals might lead one to believe that aluminum, chromium, nickel, and zinc would deteriorate rapidly, yet this is contradictory to experience with the normal water supply. The reason for the stability of these metals under ordinary conditions lies in the fact that the products of corrosion form a film protecting the metal beneath.

Electrolytic Corrosion a Part of the Problem

If an electrolytic cell is made by immersing a strip of zinc and a strip of copper in an aqueous solution of low *pH* value and the strips are electrically connected the zinc will be corroded and a current will flow from the zinc through the solution to the copper. The rapidity of corrosion and the amount of current flowing will depend upon the resistance of the circuit and the *pH* value of the solution.

The solution of iron in water follows the same law if we consider the hydrogen ions of the water as one pole in the electrical circuit. If we refer to the electromotive series of metals we find that the amount of current generated depends upon the positions relative to each other, and the metal appearing first in the series will be the metal corroded, whereas the metal following will be protected. It has been common practice on shipboard to place strips of zinc within the boilers and at the propeller shaft to protect the iron at the expense of the zinc, which could be easily replaced.

The localization of corrosion, as is customarily found in piping, may be explained by the establishment of an electrolytic cell by which one portion of the metal is protected at the expense of the other. The presence of mill scale in piping, having a different potential than the iron itself, has been frequently referred to as an accelerator of corrosion and given as the cause of pitting. If, instead of producing a current as the result of corrosion, we cause a current to flow from an external source, the portion of the piping forming the positive pole will be subject to greater pressure to enter solution depending upon the current and resistance of the

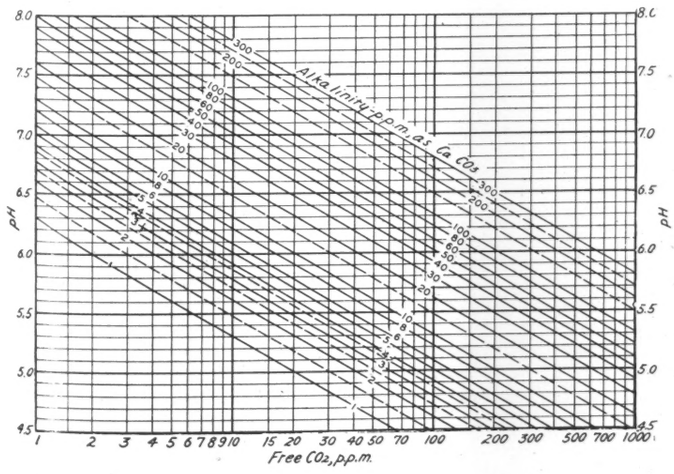


Fig. 5—Chart Showing Relation of Calcium Carbonate Hardness, CO_2 and pH Value

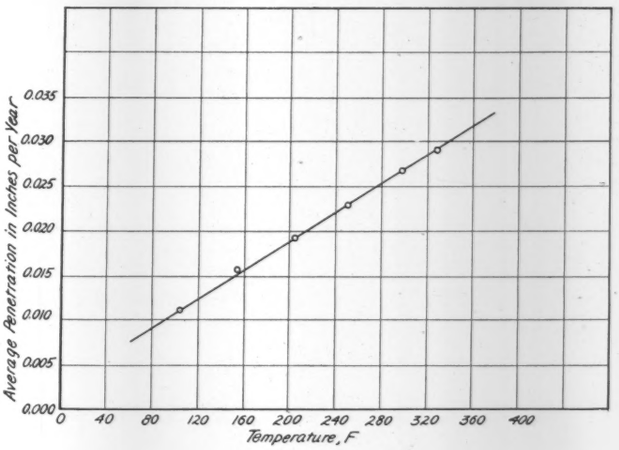


Fig. 6—Effect of Temperature on Corrosion Rate

circuit. Such corrosion is usually the result of stray current and usually is confined to underground lines near electric railroads, etc. Corrosion of this kind occasionally has been reported as a result of leakage from a direct-current generator set, but corrosion due to this cause is rare in hot-water pipe lines.

Characteristics of Water Supplies

Most normal water supplies contain the elements or compounds which cause corrosion in hot-water service lines. Surface supplies are nearly always saturated at the source with oxygen, some of which may be consumed in corrosion of the water mains. Natural water supplies also contain free carbon dioxide, present in solution as carbonic acid, H_2CO_3, which ionizes slightly and thus increases the hydrogen ionization and lowers the *pH* value. Counteracting this, most waters contain bicarbonates of calcium and magnesium, which tend to increase the *pH* value. A definite relation exists between the bicarbonate hardness, free carbon dioxide and *pH* value for natural waters as follows:

$$pH = \text{Log} \frac{\text{Alkalinity as } CaCo_3 \text{ in p.p.m.} \times 2}{CO_2 \text{ in parts per million}} \times 10^6$$

which is plotted in Fig. 5. A water low in mineral solids or carbonate hardness is likely to be more corrosive than one of relative high carbonate hardness as illustrated by Fig. 3, showing the relative corrosiveness of typical waters. The corrosive tendencies of a water may be increased by passage through a filtration system in which alum is used as a coagulant, as its action is to reduce the carbonate hardness and to increase the free CO_2.

Effect of Temperature

Speaking generally, all chemical reactions and rates of solution are accelerated by increase of temperature. The rate of rusting is a straight-line function of temperature. Thus, Speller[2] gives the relative corrosion rates as indicated by Fig. 6, the corrosion having been determined at various temperatures in a closed system, using a water containing 1.3 cc. of oxygen per liter. The water was circulated in a coil under pressure to prevent the absorption or release of oxygen.

[2] Corrosion—Causes and Prevention, Speller, p. 144, McGraw-Hill Book Co., Inc., 1926.

Keeps Patrons Cool With Ice

Hotel Installs Air-Conditioning System for Its Dining Rooms

A Corner of the Dining Room, Showing a Few of the Autographed Photographs of Distinguished Patrons. The Inlet and Outlet Grilles for the Conditioning System Were Harmonized with the Decorative Scheme; Two of Them Are Shown in This View

By Clifford F. Holske*

PRACTICALLY every visitor to our national capitol, and certainly all of those who love fine food, recall with pleasure the meals served in the dining rooms of the Occidental Hotel. The walls of the restaurant are covered with autographed pictures of distinguished guests—presidents, congressmen, supreme court justices, kings, princes and others. This gallery is of considerable interest, indicating that these notables have recognized that indefinable something in the cuisine which money cannot buy and have returned the compliment in kind. That an eating place of this caliber has recently installed an air-conditioning system is of considerable interest.

Equipment Hung From Basement Ceiling

Being skilled in the art of completely satisfying their guests, the management did not make the error of seeking a system capable of rendering the restaurant "20 degrees cooler than the street." The equipment installed comprises a complete comfort conditioning unit consisting of three full-housed centrifugal fans mounted on a single shaft, a finned refrigerating coil, a combined filter and eliminator and a bank of steam-heating coils suspended from the basement ceiling. The fans are driven by a direct-current motor, 1½ hp., 1725 r.p.m., by means of a V-belt drive.

*Test Engineer, American Ice Company, New York City.

Ducts Installed Without Interruption to Operation

The system of ducts through which the air is distributed were installed without interrupting the normal use of the dining rooms, as all work on these parts of the system was done between the hours of 5 a.m. and 10 a.m., a period in which one dining room is sufficient to accommodate the patrons. Special diffusing outlets are used at the discharge points. The air enters the restaurant horizontally through these outlets, mixing with the room air before the zone of occupation is reached, to prevent cold drafts and produce a uniform condition in the rooms by increasing the general air movement. These duct outlets are located along the front and one side of each room, the return air pick-ups being in the rear. A short duct carries fresh outside air from the street to the conditioning unit, hand-operated dampers regulating the proportions of fresh and recirculated air.

The total volume of air circulated is approximately 5000 c.f.m., about one-half of which is recirculated at the present time, although the job was calculated for 70-per cent recirculation.

The ice bunker is located in the basement near the conditioning unit and adjacent to the service elevator for convenience in icing. It is 14 ft. 4 in. long, 7 ft. 9 in. wide and 7 ft. 7 in. high, the 6-in. poured concrete wall being insulated with two layers of 3-in. corkboard

and a ½-in. plaster finish. The interior is finished off with a waterproof cement coating. The ice rests on grids constructed of cypress 2 x 4's on 4-in. centers. Ten sprays are used, the volume of water through each at the operating pressure of 2 lb. being 10 g.p.m.

Cold Water Controlled by Electrically-Operated Valve

The water piping for the cooling system is shown in an accompanying diagram. The pump is rated to deliver 100 g.p.m., and is direct connected to a d.c. motor, 230 volts, 11.6 hp. This pump delivers the cooled water from the ice bunker to the cooling unit, the water returning through a 2½-in. line to the spray system or through the bypass loop, depending upon the position of the electrically-operated valve which is controlled by a thermostat located in the dining room. When the room temperature is reduced to that point for which the thermostat is set, the valve closes, bypassing the return water. For winter operation this same thermostat is used to control a motor which operates a damper, bypassing the heating coils.

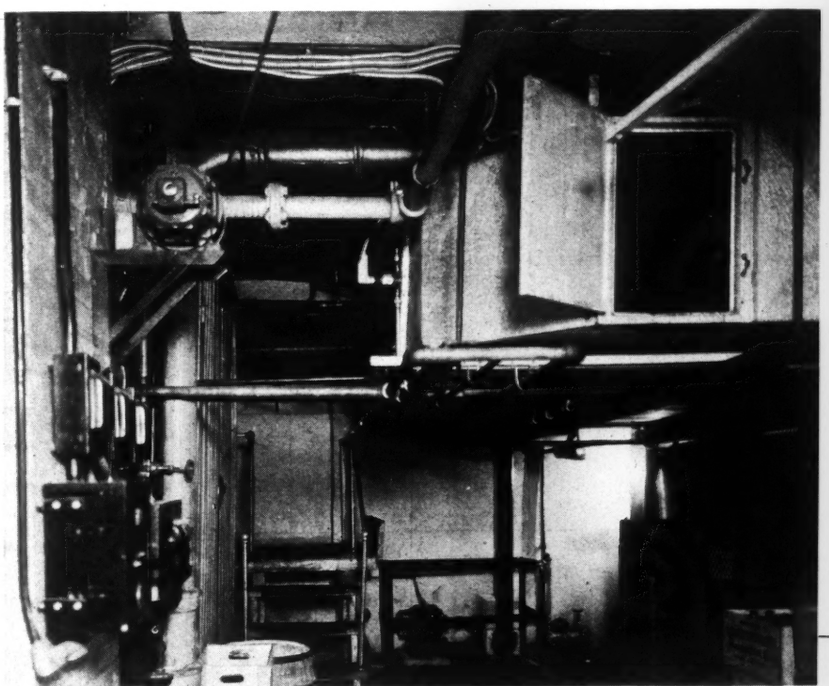
As only direct current is available it was necessary to install a ¼-hp. converter to operate the controls. In addition to the damper and valve motors mentioned, these consist of a hygrostat which operates a solenoid valve controlling humidifying sprays and a thermostatically-controlled steam valve, both used during the heating season only.

In warm weather the cooling system is operated from 11 a.m. to 10 p.m., but in moderate weather no refrigeration is used, the circulation of filtered air being sufficient to maintain comfortable conditions in the restaurant.

Typical Amounts of Ice Delivered

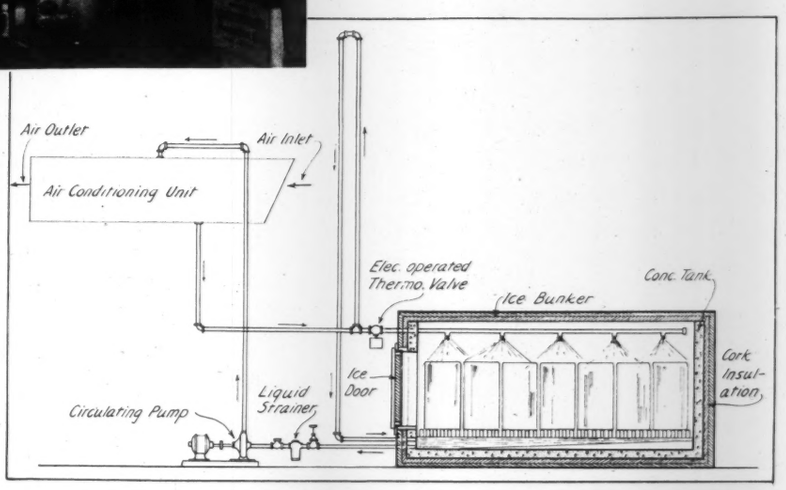
The system was completed and put in operation on June 2, 1932. The following list shows the amounts of ice delivered to the water cooling tank during the first three weeks of operation.

June	2	6000 lb.
"	4	7500 "
"	5-6	10200 "
"	7	11100 "
"	13	2400 "

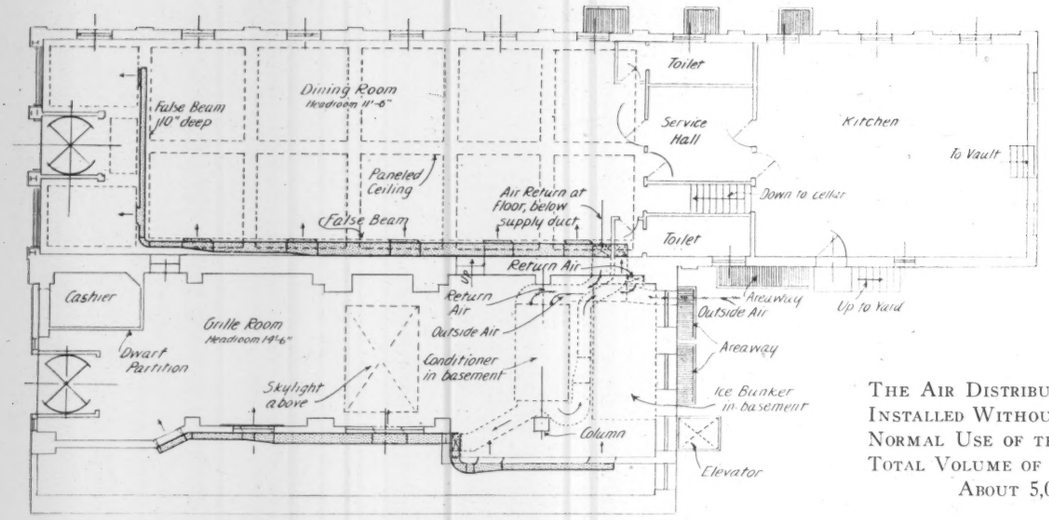


THE COOLING UNIT SHOWN ABOVE IS HUNG FROM THE BASEMENT CEILING. IN THE BACKGROUND IS SEEN THE CIRCULATING PUMP AND THE WALL OF THE BUNKER

. . . . That an air-cooling system is essential to the successful operation of practically every enterprise which depends upon attracting the public is given further support by the decision of the management of the Occidental Hotel, well-known Washington hostelry, to condition its dining rooms. The ice-cooled system described here was installed two months ago; this article presents data on the ice consumption and the air conditions maintained.



THE PUMP DELIVERS COLD WATER TO THE CONDITIONING UNIT AS SHOWN AT THE RIGHT, THE WATER RETURNING TO THE BUNKER THROUGH A 2½-IN. LINE OR THROUGH A BYPASS LOOP DEPENDING UPON THE POSITION OF THE ELECTRICALLY-OPERATED VALVE CONTROLLED BY A THERMOSTAT



THE AIR DISTRIBUTION DUCTS WERE INSTALLED WITHOUT INTERRUPTION TO NORMAL USE OF THE DINING ROOMS. TOTAL VOLUME OF AIR CIRCULATED IS ABOUT 5,000 C.F.M.

June	14	6000 lb.
"	15	10800 "
"	16	9000 "
"	18	10800 "
"	22	9600 "
"	23	10800 "

These figures indicate only the amount delivered to the ice bunker on the dates shown, and are not necessarily indicative of the ice consumed on those dates. Price of ice for this type of service may be assumed as $4.00 per ton.

Cooling Load Is 23 Tons

It should be noted in this connection that the calculated heat load for the two rooms amounted to 23 tons of refrigeration, divided about as follows:

	Btu per hr.
Sunlight through windows	35,160
Sunlight through skylight	5,760
Sunlight load through walls	3,750
Heat dissipated by 250 persons	80,000
Heat from lights—5,150 watts	17,580
Heat transmission through glass	833
Heat transmission through walls	5,640
Heat transmission through partition	2,310
Heat through floors and ceilings	27,700
Cooling 2,500 c.f.m. of fresh air	77,210
	255,943
Add 10 per cent factor of safety	25,594
Total	281,537
	or 23.4 tons

Note: Maximum outdoor temperature, 95 F dry bulb and 78 F wet bulb; maximum indoor temperature, 80 F dry bulb and 70 F wet bulb.

Test Shows Comfortable Conditions Maintained

On June 15, the following temperatures were noted in the rooms:

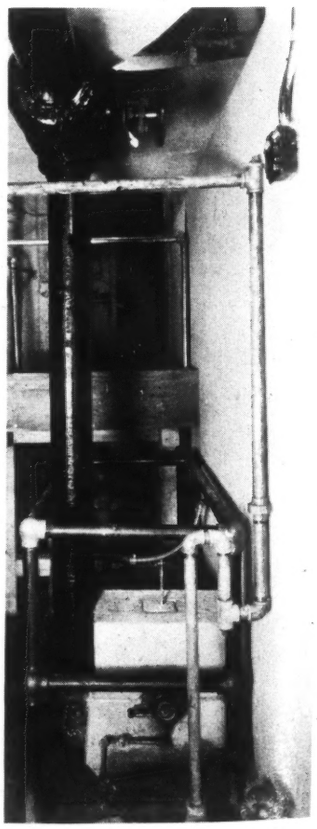
	Dry Bulb	Wet Bulb	Relative Humidity	Effective Temperature
Average 3 points near main entrance	77.5	67.6	59.3	73.6
Average 5 points in rooms	77.1	67.6	61.4	72.7
Temperature near recirculation grilles	77.0	68.0	63.0	72.8

These readings were taken between 1:30 and 2:15 p.m., at which time there were approximately 110 occupants in the two rooms. During this period the following temperatures were taken in the adjacent street:

D.B.	W.B.	R.H.	Eff. Temp.	Wind
87	77	63	81	Slight south

Management Well-Pleased with Job

The total cost of the installation, including the necessary redecoration, was slightly in excess of $8,000. The management is pleased with the appearance of the installation as well as with its operating characteristics, and has agreed to furnish information as to the increase in patronage due to the comfort cooling equipment, which will be available later in the season.



THE PUMP WHICH CIRCULATES THE COLD WATER INSTALLED AGAINST THE WALL OF THE ICE BUNKER. THE BLOCK INSULATION ON THE PUMP IS REMOVABLE

By William L. Hand

Rolling, Turning of Pipe Being Welded; How It's Prevented

New Field Building Heating System an All-Welded Job

A VITAL problem in the welding of larger pipe—say 10 in. and over—is rolling. It was solved in a novel way by the contractors installing the piping for the all-welded heating system in the new Field building development now being constructed in Chicago.

The end of a length of pipe 10, 12 or 14 in. in diameter may roll during welding as much as 3 inches out of line. A usual method is to correct this after welding by straightening the pipe, reheating certain sides of the weld and chilling with cold water, repeating this process until the main is once more in alignment. This procedure is costly in gas and time and the repeated applications of heat and cold may weaken the weld.

Turning is also a problem. In the installation of a group of valves (for instance a pressure-reducing station with a valve on each side of the pressure-reducing valve and a large-size bypass with a valve, or a header including a number of valves and branches) flanges and branches may turn and bend completely out of line so that the bolt holes will not line up and the flanges are turned so as to make it impossible to connect them up.

How Rolling and Turning Were Prevented

Contrary to the view that a weld once started should be completed and that the use of two torches on one joint results in poor welding, excellent results insofar as eliminating the above difficulties were obtained by the following procedure:

A considerable amount of a straight line or an entire group of valves, flanges, pipe pieces, welding fittings and pipe was erected at one time, all valves and flanges bolted together and the entire section secured by spot welding each joint at two or more points. Welding was then started simultaneously on two or four joints on the same pipe which were in line, each weld proceeding on opposite sides of the pipe line for about one-quarter to one-third of each joint; at this point welding was stopped. Welding was then started on two or four joints on a branch line of the same group (such as a by-pass), proceeding in the same manner, always welding simultaneously on opposite sides of the same line of pipe for about one-quarter to one-third of each joint and stopping at intervals to allow cooling and contraction.

Welding was then resumed on the first group of joints for one-quarter or one-third, always welding simultaneously on opposite sides of a line to create opposing forces which would react against each other. Again welding was stopped and resumed on the second group of joints, alternating from one group of joints to the other until all welding was completed.

The problem of shortening or lengthening of the pipe was solved in much the same manner, by erecting as one unit as much of a header or branch as possible, spot welding as described above and proceeding by partly welding opposite joints on opposite sides and opposite ends of the header, working the forces against each other. When headers with a number of branches shorten or lengthen, not only are valves and flanges turned out of line but often cutting and rewelding is necessary.

One of the interesting things to Mr. Hand, who has had wide experience in the design of heating and piping systems, about the new Field office building, was the method used by the contractors to prevent rolling, shortening or lengthening of the pipe while welding. He tells how it was done in this article and describes how distortion of flanges, valves, etc., was eliminated.

Steam at 5-lb. pressure is supplied this building by five water-tube boilers operating at 100 lb. The heating system is divided into three parts, the first embracing the first to fourth floors with upfeed from a basement distribution main, the second comprising the fifth to twenty-fourth floors upfed from a basement main and the third includes the tower floors (twenty-fifth to forty-fifth floors), down fed from a main at the forty-fifth floor.

The entire heating system is welded. Exclusive of the requirements for heating the ventilating air, there are 116,500 sq. ft. of radiation and a total of 174 risers.

Piping Must Keep Pace With the Building

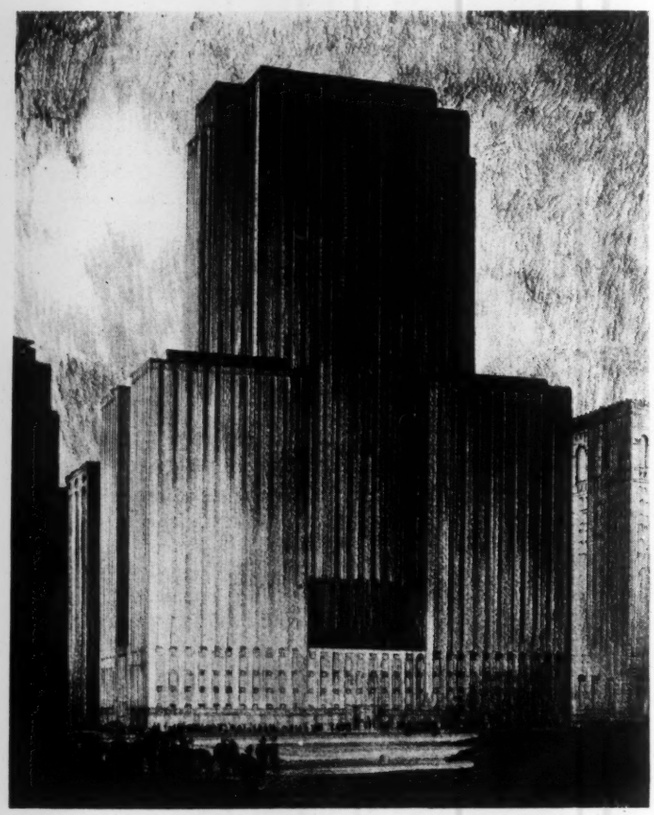
Installing a heating system in a modern building requires well organized plans as the installation must go up with the building. All parts of the Field installation, and in particular risers, radiator branches and connections, were detailed and models were set up showing typical radiator connections. All risers were delivered at the building with beveled ends in random lengths, erected and welded in place, allowing riser joints at any point between floors, with the erection proceeding with the erection of the steel structure. Into each supply and return riser was installed and welded a ¾-in. and a 1-in. radiator branch pipe, bent 90 degrees on a radius of 6 in. with a 12-in. and a 24-in. end from the bend, with the long end extending from the riser to and into the radiator recess.

While the erection of risers was progressing with the erection of the steel structure, work of installing the basement distribution mains proceeded, completing the installation of both mains and risers at the same time.

¾-in. Connections Welded

All the supply and return mains, headers, branches, risers and connections to heating coils and equipment are of standard-weight wrought-iron pipe.

It is interesting to note that standard-weight pipe and welding fittings were used on all pipe sizes from the largest mains to the ¾-in. branches without experiencing any trouble. This was done by the careful use of small welding tips which produced a well-made welded joint without burning or warping of pipe or fittings on either small or large lines.



ARCHITECT'S DRAWING OF THE NEW FIELD OFFICE BUILDING IN CHICAGO'S FINANCIAL DISTRICT. THE DEVELOPMENT WILL BE CONSTRUCTED IN THREE SECTIONS AND WILL COVER A GROUND AREA OF 60,800 SQ. FT.; THE FIRST SECTION IS PRACTICALLY COMPLETED. GRAHAM, ANDERSON PROBST AND WHITE ARE THE ARCHITECTS; ROBERT GORDON, INC., THE HEATING CONTRACTORS. CHARLES LEHN IS CHIEF ENGINEER FOR FIELD ESTATE

Caring for Expansion

Branch connections between mains and risers and all branches from mains and risers are installed with the customary two elbow turns at the base or at the top of each riser to allow for expansion and movement. Risers include weld-end slip-expansion joints back of access panels, with radiator branches from the risers made of 6-in. radius pipe bends, welded into the front of the riser, turning and extending into the radiator recess, to allow for the up-and-down movement of risers.

Branches from mains or headers to equipment or heating coils are also installed to allow for movement, the branches being made with 45-deg. turns at the mains, and two or more 90-deg. turns at the connections to the equipment, heating coils, pumps and boilers. This is necessary to avoid the pulling of mains out of line, pulling equipment out of location, sagging mains and branches which would cause air and water trapping, straining valves and joints, and breaking lines.

Little Cutting Required on the Job

Very little cutting was required in the erection of the risers, as they were delivered in random lengths with beveled ends and erected into place, welding the connecting joints at random points between floors. The radiator branches were delivered bent as mentioned above ready to weld into the risers on each floor.

As with the risers, the installation of the distribution mains required little cutting at the building, the pipe being delivered in random lengths with beveled ends, and erected into place with no particular location of joints, with the branch lines to risers, equipment and heating coils cut and welded into the mains after erection of the mains.

Radiator Branches and Connections of Copper

From the end of the 90-deg. bent piece from the risers, the branch supply and return lines to the concealed radiators and the connections to radiators are made of 1-, ¾- and ½-in. seamless copper tubing with wall thicknesses of 0.04 in., 0.045 in. and 0.05 in. respectively.

The tubing was cut at the building with power saws, the ends sandpapered clean and coated with a soldering paste. The tubing was then connected with special copper sweat fittings, heated with a gasoline torch and floated with solder,

CORKBOARD BEING APPLED TO A ROOF

By . . . . . .
Ralph Winslow*

Prevents Damaged Goods, Rusty Machinery

Roof Insulation Stops Condensation and Drip—Chart Makes Easy Figuring

SINCE high-humidity rooms are an essential part of certain processes in both textile and paper mills (as well as in other industries), the problem of roof condensation and drip, with consequent damage to goods, is an important one.

Under severe conditions such as are encountered in machine rooms in paper mills, and in weaving rooms and dye houses in textile mills, the manufacturer is faced with the problem of "doing something about it" or suffering a large percentage of damaged goods and increased overhead.

Condensation is caused by the high heat transmission of uninsulated roof decks. A roof which leaks heat is colder on its underside than the warm humid air which rises and strikes it. Naturally, condensation occurs, and when it does so in large amounts, water drips down upon the machinery, goods and workmen below.

Condensation and drip, however, are not the only problems confronting the paper or textile mill if wooden roof decks are uninsulated. The moisture in the highly humid air is readily absorbed by such roofs. This promotes certain fungus growths which hasten the necessary replacement. The United States Department of Agriculture, Forest Products Laboratory, pointing out this danger, says: "Dampness favors the growth of fungi which destroy wood. . . . In factories or mills where there is much moisture present or where high humidities are maintained, as is often done in paper mills, weaving mills, and dye houses, moisture is likely to collect on the wood in considerable quantity and promote rapid decay. Roof planking in such buildings is especially likely to collect moisture by condensation."

*Armstrong Cork Company, Lancaster, Pa.

Various kinds of insulation are used for paper and textile mill roofs. Corkboard is one type that is commonly used.

Roof Insulation of a Textile Mill

Although definite examples are not the absolute criteria as to whether or not roof insulation is worthwhile in any given plant, they are at least valuable because conditions may be comparable or vary in such a way that definite conclusions can be drawn nevertheless.

The Jackson Mills of the Nashua Manufacturing Company, of Nashua, N. H., for instance, are representative textile mills which have achieved sizeable savings through the use of roof insulation. In this case the spinning department concrete slab roof, embracing 7,220 sq. ft., was the chief offender, since it caused a particularly difficult drip and condensation problem.

The Jackson Mills are housed in a modern reinforced concrete building completely equipped for the working of raw cotton into unbleached cotton cloth. Set-back construction is used; the three lower floors being 123 ft. x 560 ft., the fourth and fifth floors 123 ft. x 420 ft. and the sixth floor 123 ft. x 155 ft. Ceiling heights are 15 ft. on each of the five lower floors and 14 ft. 9½ in. on the top floor. Air conditioning equipment typical of progressive textile mill practice, and temperature and humidity calculated to assure uniform high quality of product and minimum of end breakage, are provided.

Condensation trouble developed in the spinning department the first winter following the opening of the mill. This department is on the third floor of the building which embraces an area of 123 ft. x 560

ft. Since the next floor is only 123 ft. x 420 ft. there is an exposed roof area of 123 ft. x 140 ft. over the spinning department.

Relative humidity is maintained at 65 per cent and temperature at 70 to 75 F. During the winter months heat transfer through the roof was enough to bring the

Chart Shows Economical Thickness of Corkboard

The chart and table published here can be used with good results as a simple means to determine the proper thickness of corkboard roof insulation to use in any given case. The only factors which it is necessary to know for this purpose are the maximum temperature difference between the inside and outside, the kind and type of roof deck, and the relative humidity of the rooms.

The method of using the chart and roof resistance table is as follows:

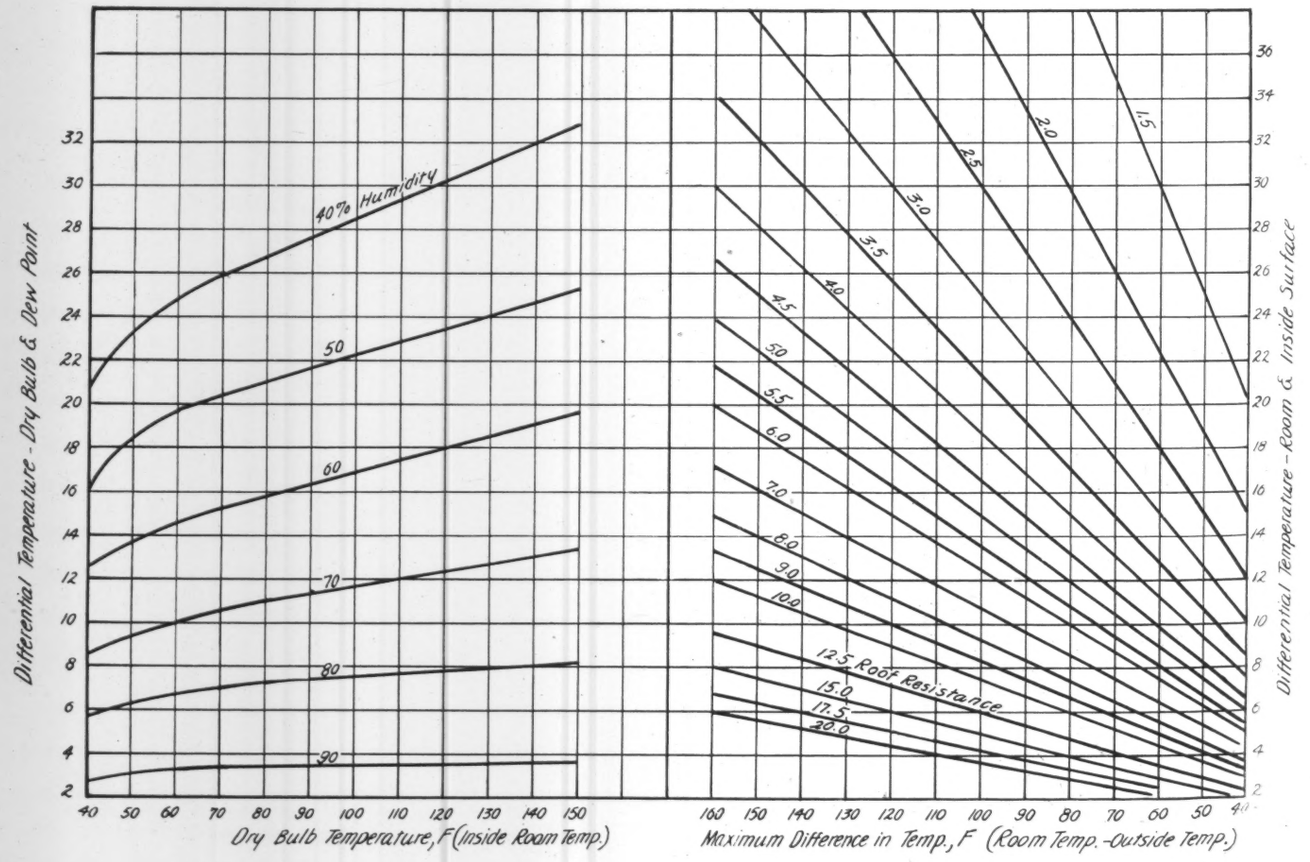
First, locate at the bottom, left, of the chart, the inside room temperature in degrees Fahrenheit. Follow upward until this line intersects the line of humidity percentage. From the point of intersection follow the horizontal line to the right to its intersection with the line of maximum temperature difference. The point of intersection is then read as the roof resistance required for the total roof structure, including insulation. Reference is then made to the roof resistance table for the construction and insulation.

Example: Assume a plant in which it is wished to prevent condensation, where the maximum relative humidity is 78 per cent, the inside temperature 70 F, and the minimum outside temperature is —10 F. Thus the maximum temperature difference is 80 F. The building has a 4-in. concrete roof slab. Turning to the chart locate 70 F (inside temperature), where it meets 78 per cent (relative humidity). Follow a straight line to the right until it meets 80 F (maximum temperature difference). The point of intersection gives the heat resistance necessary to prevent condensation. In this case the required resistance is indicated as 7.6.

Turning to the table following, the resistance of a 4-in. concrete slab with roofing is found to be 1.76. To raise the total resistance to 7.6, it is necessary to add corkboard in thickness sufficient to add 7.6—1.76, or 5.84. If the resistance of 1-in. of corkboard is 3.33[1], the thickness required will be 5.84 ÷ 3.33, or 1.74. The nearest standard thickness of corkboard is 2 inches.

By another method, after determining the necessary resistance to be 7.6, turn to the table and run down the list of resistances under 4-in. concrete in the table until the nearest resistance to that required is located, in this case 8.40, which is the resistance given for 4-in. concrete and roofing with the addition of 2 inches of good quality corkboard.

[1] Resistance is the reciprocal of conductivity; in this example $\frac{1}{0.30} = 3.33$.



CONDENSATION CHART WHICH IS USED WITH THE TABLE ON THE NEXT PAGE FOR SELECTING THE PROPER THICKNESS OF CORKBOARD FOR ROOF INSULATION

temperature on the under-side well below the dew point and to cause condensation and drip.

Condensation also occurred on the outside walls. The extent of trouble from this source alone can be judged by the fact that water running down the walls wetted the floor sufficiently to cause machine operators to wear rubbers at their work.

Losses resulted from quite a few sources. Ceiling drip causes spotted yarns which in turn causes some of the finished goods to be classed as second quality. The ceiling drip also causes a great deal of rusting of equipment and machinery, leading to abnormally rapid depreciation. Pleasant working conditions for the employes were likewise impossible.

Wall condensation was reduced by the installation of heating coils, and a system of gutters served to carry off whatever remained.

However, the more important problem resulting from ceiling condensation remained. This trouble was eliminated by roof insulation. The original roof of 9½-in. flat slab reinforced concrete was provided with a drainage slope by adding a cinder concrete fill. A five-ply standard specification tar and gravel covering completed the original roof. One inch of corkboard was then laid over the concrete fill and covered with five-ply roofing. The job required about 17,220 board feet of corkboard.

ROOF RESISTANCE TABLE—CORKBOARD

CONSTRUCTION	RESISTANCE FACTOR[a]	TRANSMISSION IN BTU PER SQ. FT., PER F TEMP. DIFF. PER HOUR
2″ Concrete Slab and Roofing, No Insulation	1.52	0.66
2″ Concrete Slab and Roofing with 1″ Corkboard and Roofing	4.86	0.21
2″ Concrete Slab and Roofing with 1½″ Corkboard and Roofing	6.54	0.15
2″ Concrete Slab and Roofing with 2″ Corkboard and Roofing	8.19	0.12
2″ Concrete Slab and Roofing with 3″ Corkboard and Roofing	11.52	0.09
2″ Concrete Slab and Roofing with 4″ Corkboard and Roofing	14.86	0.07
3″ Concrete Slab and Roofing, No Insulation	1.64	0.61
3″ Concrete Slab and Roofing with 1″ Corkboard and Roofing	4.97	0.20
3″ Concrete Slab and Roofing with 1½″ Corkboard and Roofing	6.62	0.15
3″ Concrete Slab and Roofing with 2″ Corkboard and Roofing	8.34	0.12
3″ Concrete Slab and Roofing with 3″ Corkboard and Roofing	11.67	0.09
3″ Concrete Slab and Roofing with 4″ Corkboard and Roofing	15.00	0.07
4″ Concrete Slab and Roofing, No Insulation	1.76	0.57
4″ Concrete Slab and Roofing with 1″ Corkboard and Roofing	5.10	0.20
4″ Concrete Slab and Roofing with 1½″ Corkboard and Roofing	6.75	0.15
4″ Concrete Slab and Roofing with 2″ Corkboard and Roofing	8.40	0.12
4″ Concrete Slab and Roofing with 3″ Corkboard and Roofing	11.73	0.09
4″ Concrete Slab and Roofing with 4″ Corkboard and Roofing	15.07	0.07
6″ Concrete Slab and Roofing, No Insulation	2.00	0.50
6″ Concrete Slab and Roofing with 1″ Corkboard and Roofing	5.32	0.19
6″ Concrete Slab and Roofing with 1½″ Corkboard and Roofing	6.99	0.14
6″ Concrete Slab and Roofing with 2″ Corkboard and Roofing	8.68	0.12
6″ Concrete Slab and Roofing with 3″ Corkboard and Roofing	12.00	0.08
6″ Concrete Slab and Roofing with 4″ Corkboard and Roofing	15.35	0.06
1¾″ Yellow Pine and Roofing, No Insulation	2.90	0.34
1¾″ Yellow Pine and Roofing with 1″ Corkboard and Roofing	6.25	0.16
1¾″ Yellow Pine and Roofing with 1½″ Corkboard and Roofing	7.93	0.13
1¾″ Yellow Pine and Roofing with 2″ Corkboard and Roofing	9.51	0.10
1¾″ Yellow Pine and Roofing with 3″ Corkboard and Roofing	12.84	0.08
1¾″ Yellow Pine and Roofing with 4″ Corkboard and Roofing	16.17	0.06
2¾″ Yellow Pine and Roofing, No Insulation	3.91	0.26
2¾″ Yellow Pine and Roofing with 1″ Corkboard and Roofing	7.25	0.14
2¾″ Yellow Pine and Roofing with 1½″ Corkboard and Roofing	8.93	0.12
2¾″ Yellow Pine and Roofing with 2″ Corkboard and Roofing	10.52	0.10
2¾″ Yellow Pine and Roofing with 3″ Corkboard and Roofing	13.85	0.07
2¾″ Yellow Pine and Roofing with 4″ Corkboard and Roofing	17.19	0.06
Sheet Steel Deck and Roofing, No Insulation	1.28	0.78
Sheet Steel Deck and Roofing with 1″ Corkboard and Roofing	4.61	0.22
Sheet Steel Deck and Roofing with 1½″ Corkboard and Roofing	6.25	0.16
Sheet Steel Deck and Roofing with 2″ Corkboard and Roofing	7.94	0.13
Sheet Steel Deck and Roofing with 3″ Corkboard and Roofing	11.27	0.09
Sheet Steel Deck and Roofing with 4″ Corkboard and Roofing	14.61	0.08
4″ Hollow Tile, ⅝″ Roofing, No Insulation	3.00	0.33
4″ Hollow Tile, ⅝″ Roofing with 1″ Corkboard and Roofing	6.00	0.17
4″ Hollow Tile, ⅝″ Roofing with 1½″ Corkboard and Roofing	7.67	0.13
4″ Hollow Tile, ⅝″ Roofing with 2″ Corkboard and Roofing	9.34	0.11
4″ Hollow Tile, ⅝″ Roofing with 3″ Corkboard and Roofing	12.67	0.08
4″ Hollow Tile, ⅝″ Roofing with 4″ Corkboard and Roofing	16.00	0.06
6″ Hollow Tile, ⅝″ Roofing, No Insulation	3.47	0.29
6″ Hollow Tile, ⅝″ Roofing with 1″ Corkboard and Roofing	6.80	0.15
6″ Hollow Tile, ⅝″ Roofing with 1½″ Corkboard and Roofing	8.47	0.11
6″ Hollow Tile, ⅝″ Roofing with 2″ Corkboard and Roofing	10.13	0.10
6″ Hollow Tile, ⅝″ Roofing with 3″ Corkboard and Roofing	13.47	0.08
6″ Hollow Tile, ⅝″ Roofing with 4″ Corkboard and Roofing	16.80	0.06

[a] Total resistance is the reciprocal of transmission.

Paper Plant Prevents Spoilage

Equally good results, although of a somewhat different nature, were obtained by the New Haven Pulp and Board Company of New Haven, Connecticut, where cork insulation was used for eliminating ceiling condensation and drip in their machine room.

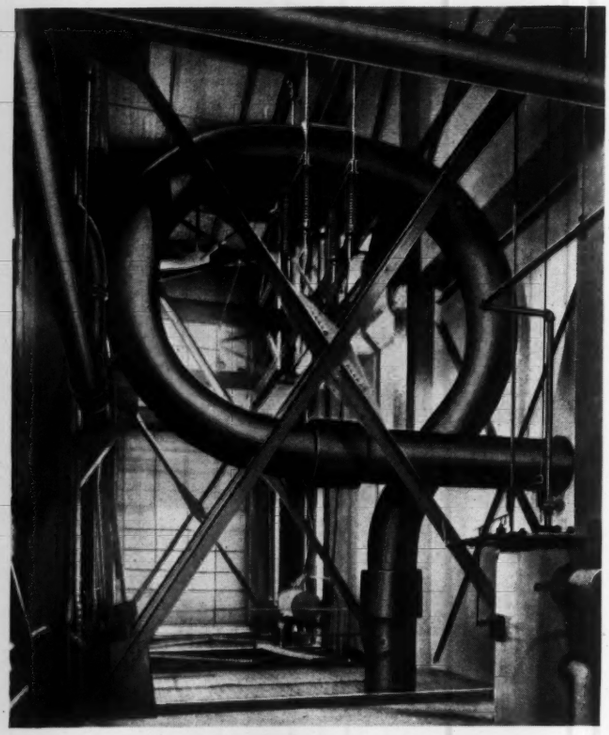
This company manufactures paper for box-making as well as small quantities of card and sheet stock for printing. The building is of one-story brick construction about 50 ft. x 300 ft. with a ceiling about 25 ft. high. The wet pulp, and the steam heated dryers used, causes an evaporation of two pounds of water for every pound of finished paper. Humidity varies from 30 per cent on the dry end of the machine to 100 per cent on the wet end and temperature varies during the fall and winter months from 55 to 60 F.

A pre-cast cement tile roof, which was given enough slope so that the water would shed properly, was installed. The joints of the tile were sealed with roofing cement and 2-in. slabs of cork were cemented to the outside surface. This has eliminated the condensation and drip which caused paper spoilage on the finished end of the machine.

Advantages of proper roof insulation are demonstrated clearly by the experiences of these two mills. Heating and fuel costs were reduced considerably. Since insulation prevents the cold outside air from cooling the under-side of the roof deck and causing condensation, it likewise prevents the warm inside air from being conducted through the roof and dissipated into the atmosphere. In the summer-time factory areas under an insulated roof are much more comfortable.

Leak-Tight Joints 600 to 550,000 Lb.

By F. E. Wertheim*



14-In. Main Steam Lead to Turbine, Great Western Power Co., San Francisco, Calif.

DESIGN of joints for high-pressure piping which will remain tight under the conditions imposed by various classes of service is a major piping problem. The purpose of this article—and of the writer's article published on page 469 of last month's issue—is to discuss various types of joints which have successfully met these conditions and to present comprehensive data concerning them. A feature of this paper is a description of the "Unsupported Area" principle developed by Dr. Percy W. Bridgman in his experiments with pressures of 550,000 lb. per sq. in., a force equivalent to that which would be exerted at the base of a column of water 240 miles high.

A. S. A. Tongue-and-Groove Joints

Tongue-and-groove joints with American steel flange standard facings have the advantage of totally confined gaskets and relatively high gasket compression. Some difficulty is frequently experienced in inserting the gaskets when installing these joints, and especial care in the drafting room, purchasing and receiving departments, and in the field, is necessary to insure correct matching of the tongues and grooves of adjacent parts in the piping system. With some of the larger sizes of the small tongue-and-groove standard, difficulties have been experienced as the result of permanent deformation of the tongue.

Ring Joints

Double-groove plain-ring joints, Fig. 1, require only one type of facing for flanges, fittings and valves. The grooves conform to the small groove standard of the *A. S. A.*, and the rings are dimensioned to clear both inner and outer walls of the groove by 1/64 in. We have, therefore, a flat unconfined gasket with sufficient inherent strength to withstand the disruptive forces of high-pressure steam. The ring, of seamless steel, is plated with a soft metal selected to resist the action of the gas or liquid to be handled. This joint is frequently made up with asbestos fiber or other gaskets placed on both sides of the ring.

The Wedge-Ring Joint

The utility of the soft steel gasket of (approximately) elliptical cross-section, Fig. 2, was probably discovered in oil refinery work when high-pressure-and-temperature equipment came into general use. Joint leakage is especially dangerous for this service because of fire hazards, and the tendency toward leakage is noticeable because of severe corrosion problems. Because of coking of the lines, refinery practice demands joints which can readily be taken apart and reassembled. For high-pressure steam apparatus, too, this joint is finding increased application. Hydrostatic tests on high-pressure valves of several makes having wedge-ring bonnet joints have demonstrated that the bonnet joints will remain tight under maximum pressures.

Valves and flanges for the Purdue high-pressure experimental boiler (*16*)[1], fitted with wedge-ring joints,

[1] See Bibliography.

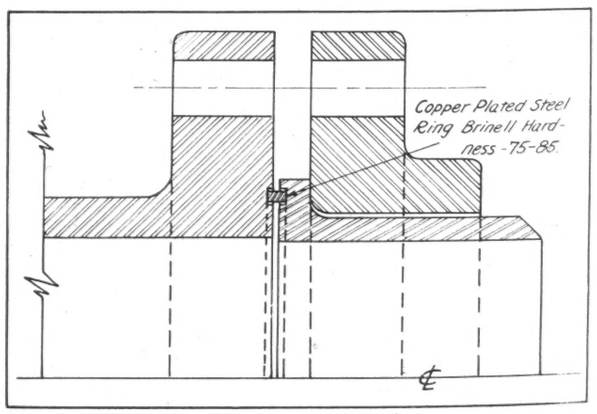


Fig. 1—Double-groove Ring Joint for 900 Lb. W. S. P. — A. S. A. Small Groove. Rings Are Sometimes Coated with Silver or Other Metal

*Associate Member *A.S.M.E.*

have proved satisfactory under pressures as high as 3700 lb. per sq. in. and temperatures of 830 F. The flanges, without insulation, have been subjected to rapid and extreme temperature fluctuations due to the characteristics of this type of boiler, and have remained tight.

In analyzing the successful applications of ring joints just cited, certain special conditions are found which do not obtain for all installations. For instance, because of the periodic dismantling necessary in refinery lines, the joints are constantly re-tightened, whereas in power-plant service joints are expected to remain tight, without further attention, for a long time after the line has been tested. Again, in refinery service, the carbon present in the lines will pack into the wedge-shaped opening adjoining the inner contact surface of the ring and this packed carbon acts as a seal.

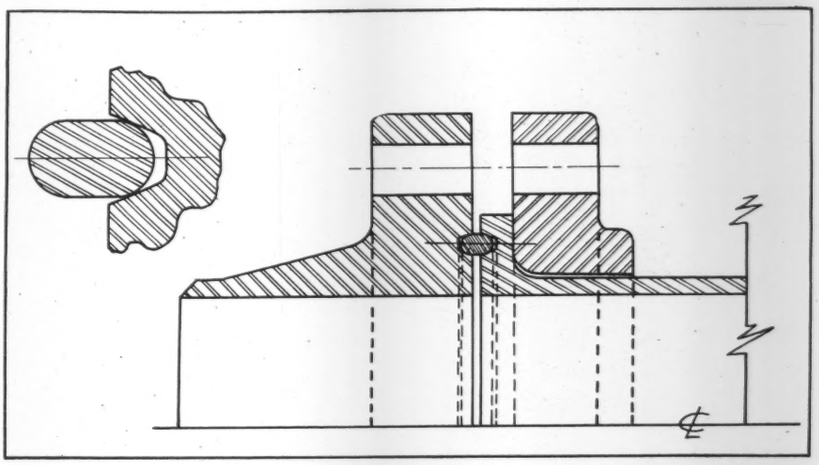


FIG. 2—600 LB. W. S. P. LOOSE WEDGE-RING JOIN

The Purdue wedge-ring joints, although satisfactory for service involving both very high pressure and temperature, are of small diameter and therefore used on small and relatively flexible lines, not subject to severe vibration or hammer, as might be the case with small hydraulic piping.

Although this joint has proved most satisfactory for valve bonnets, blind flanges and similar purposes where not subject to stresses incident to expansion and contraction of the line, it should be remembered that this design has relatively small contact surfaces and consequently *might* not be suitable for enduring severe stresses due to the weaving of a large-sized, and comparatively stiff, steam line.

Leak-Tight Joints at 550,000 Lb. per Sq. In.

Dr. Percy W. Bridgman, in his laboratory research (*1*), has burst thick-walled blocks of unhardened high-carbon tool steel having a tensile strength of about 142,000 lb. per sq. in., by subjecting them to pressures of 568,000 lb. per sq. in. (Note that the bursting stress is four times the tensile limit.) These experiments, requiring the maximum pressures ever attained, not only constitute valuable research but are important because of possible industrial application.

In these laboratory experiments, development of an improved packing technique was an imperative prerequisite. Totally confined flat gaskets, similar to those of the tongue-and-groove type, are credited to the physicist, Amagat. In this type, when the liquid or gas pressure reaches an intensity (i. e., pressure per unit area) equal to the pressure per unit area imposed upon the gasket, there is balance, with the packing exactly filling the groove or recess. With increase of gas or liquid pressure, the packing is forced away from the retaining walls, and leakage results. This type of joint has been used in laboratory apparatus for pressures up to 40,000 lb. per sq. in.

For higher pressures, Doctor Bridgman developed the new "Unsupported Area" principle, illustrated in Fig. 3. In the application of this principle the apparatus is so proportioned that the pressure per unit area of the packing exceeds the pressure per unit area of the gas or liquid by a fixed percentage. In Fig. 3, this percentage is based upon the ratio of the area of the collar and the end of tube to the annular area of the collar, i. e., area "A_2-A_1" to area "A_2-B_1." Leak cannot occur until the integrity of the packing or strength of the containing walls is impaired.

For the maximum pressures Doctor Bridgman modified the design of Fig. 3, retaining the basic "Unsupported Area" principle and employing the construction shown in Fig. 4. The lead packing will hold until flow of the machine-steel ring nearly fills the open triangular space. For extreme pressures the alloy steel tubes have a ratio of O. D. to I. D. of ten to one.

To summarize, a gasket of the "Unsupported Area" type is under bolting pressure and liquid pressure, with greater intensity of pressure in the gasket than in the liquid, giving a joint of high efficiency.

Union for Small Size High Pressure Tubing

The Fixed Nitrogen Research laboratory of the U. S. Department of Agriculture, Washington, D. C., has

An interesting feature of this article is the description of the "Unsupported Area" principle developed by Dr. Percy W. Bridgman in his experimental work with a pressure of 550,000 lb. per sq. in.—equivalent to a column of water 240 miles high. Other joints which have successfully met the conditions imposed by various classes of high-pressure service, and discussed here, are tongue-and-groove joints, wedge ring joints, a union for small-size high-pressure service and a joint for large-diameter apparatus.

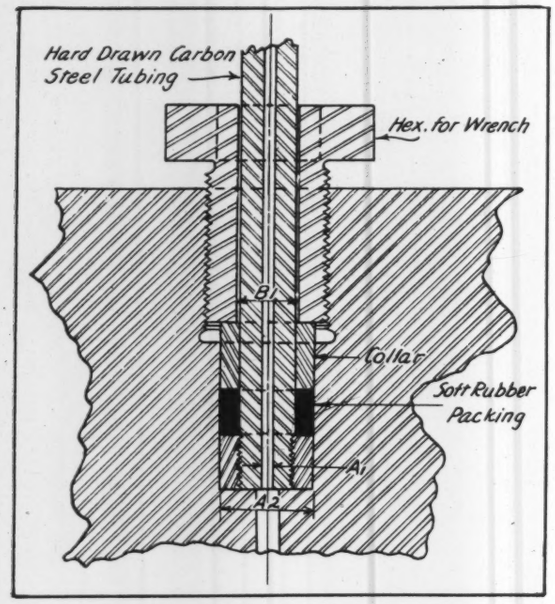


FIG. 3—DESIGN BY DR. BRIDGMAN ILLUSTRATING PRINCIPLE OF "UNSUPPORTED AREA" USED FOR PRESSURES UP TO 56,000 LB. PER SQ. IN.

solved perplexing problems in the safe employment of high pressures, the difficulties incident to high temperatures and corrosion sometimes having to be overcome at the same time. One important element in equipment for high-pressure reactions is a union for small tubing which will allow the apparatus and tubing to be readily dismantled.

F. A. Ernst[2], who developed much of the laboratory equipment, recommends the union shown in Fig. 5 for tubing with sufficient wall thickness to permit thread cutting (*3*). In assembling, parts 1 and 4 are screwed on the tubing ends, the gasket 3 (cupped for convenience in assembling) is inserted, and the joint is made up by screwing part 2 onto 1. For final tightening, a quarter turn of 1 in 2 will result in a gasket compression of about 0.003 in. due to the differential screw arrangement. The ends of the tubes have 60-deg. grooves 1/32 in. deep. One-inch chrome vanadium tubing (1% Cr, 0.2% V, 0.35% C) was used, this alloy weighing approximately half as much per foot length as ordinary carbon-steel hydraulic tubing of equal strength. In using such alloy steels economies were effected by use of much smaller tubes, valves and fittings. This connection has been entirely satisfactory for pressures of 4400 lb. per sq. in. and, with slight modifications, has been applied to joints between tubing and either valves or fittings.

Joint for Large-Diameter Apparatus

Among the various types of equipment in which avoidance of difficulties due to leakage or to joint maintenance troubles are of highest importance are tubular heat exchangers. A recently developed heater, Fig. 6, clearly indicates that joints are both a factor and a feature in the design of such apparatus. Definitely confined thin and narrow metal gaskets, sealed by means of a "nubbing ring" ⅛ in. wide by 1/64 in. high as illustrated in Figs. 7, 8, and 9, are subjected to high unit pressure by bolts so located as to produce minimum bending stresses and deformation in flanges or in hook bolts. The high-pressure portion of this heat exchanger consists entirely of forged or rolled units made from thoroughly killed steel[3].

These heat exchangers are in use under pressures of 750 lb. per sq. in., having first undergone preliminary shop tests proving them bottle tight at 4500 lb. per sq. in. hydrostatic pressure. They are said to have remained tight under this pressure even when alternate bolts were loosened. Although use of this type of construction has so far been limited to 36-in. diameter, there does not appear to be any reason why it would not be applicable to larger sizes.

Conclusions

(1) Joint design, based on engineering principles, is being more firmly established.

(2) For pressures above 400 lb. W. S. P. the recent trend has been to confine gaskets or to eliminate them.

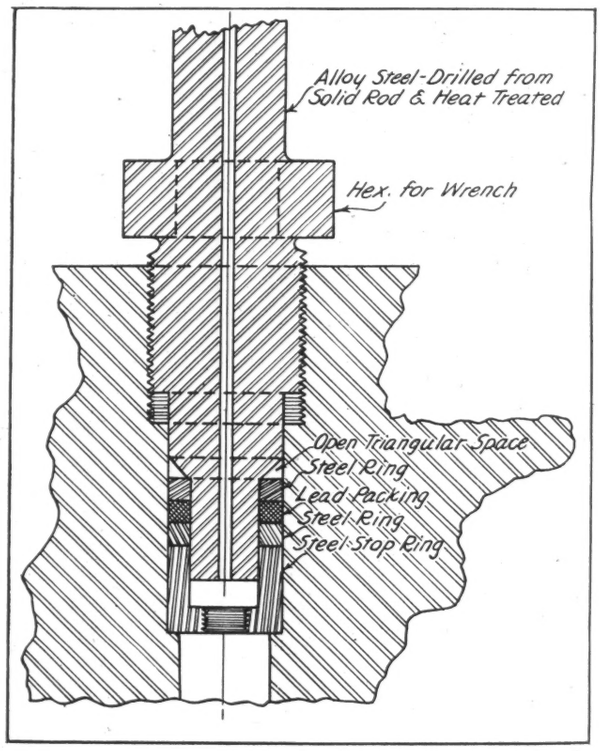


FIG. 4—PACKED JOINT USED FOR HIGHER PRESSURES DESIGNED BY DR. BRIDGMAN

(3) Ring gaskets are finding increased application and their use should be advantageous for many high-pressure services. The writer believes that standardization of ring joints by the *A. S. A.,* for pressures from 300 lb. to at least 2000 lb. per sq. in., would be most desirable.

[2] Fixed Nitrogen Research Laboratory, Washington, D. C.

[3] Killed steel is a steel so thoroughly degasified in the furnace, either open hearth or electric, that when poured there is no boiling or flaming effervescence. The other kind of steel is known as "open" or "rimmed" steel.

(4) The ideal joint is one which will remain tight up to the bursting pressure of piping or connected apparatus. Because bolt and flange stresses due to operating conditions may be super-imposed upon those required for high pressure and tightness, the foregoing specification may not be any too severe.

Acknowledgment

The writer extends thanks to Messrs. F. W. Martin, W. F. Lahl, and F. C. Fantz, for valuable assistance. The many references consulted[4] have been listed in the following:

Bibliography

1. The Physics of High Pressure, by P. W. Bridgman, McMillan, 1931.
2. Some Considerations Affecting Future Development of the Steam Cycle, presented before *Institution of Mechanical Engineers (Northwestern Branch)* by K. Baumann. Published in *Engineering*, Nov. 7, 1930; Nov. 21; and Dec. 5.
3. Equipment for High-Pressure Reactions, by F. A. Ernst, *Ind. & Eng. Chem.*, July, 1926, p. 664.
4. Metallurgical Requirements for High Temperature Steam Piping, by F. W. Martin, from *A. S. M. E.-A. S. T. M.* "Symposium on Effect of Temperature on the Properties of Metals" and reprinted in HEATING, PIPING AND AIR CONDITIONING, August, 1931, p. 673.
5. Design of Flanged Pipe Joints, by Sabin Crocker, HEATING, PIPING AND AIR CONDITIONING, Aug., 1929, p. 293; Sept., 1929, p. 396; and Oct., 1929, p. 497.
6. Pipe Joints for 1000 F Service, by Arthur McCutchan, HEATING, PIPING AND AIR CONDITIONING, Nov., 1931, p. 918.
7. Why Flanged Pipe Joints Leak, by Arthur McCutchan, *Power*, Sept. 10, 1929, p. 414.
8. Keeping Steel Gaskets Tight at 1350 Lb., by W. P. Saunier, *Power*, July 1, 1930, p. 22.
9. Stresses on Bolts, Nut Dimensions, Wrench Design, by Geo. S. Case, *Mechanical Engineering*, Sept., 1926, p. 919.
10. Valves and Boiler Fittings for 1900 Lb. and 900 Deg., by Bruno Belohlavek and Arthur J. Herschmann, *Power*, June 30, 1931, p. 1028.
11. Joint for 1400 Lb. W.. S. P. at 900 F., by R. C. Allen, *Power*, July 7, 1931, p. 26.
12. A Pipe Joint for High Air Pressure, by F. A. Halsey, *Trans. A. S. M. E.*, 1899, p. 745.
13. Gaskets and Packing for Hydraulic Power, by F. E. Wertheim, HEATING, PIPING AND AIR CONDITIONING, March, 1932, p. 203.
14. Testing Couplings to Withstand High Pressure, by J. K. Crowell, *Gas Age-Record*, May 17, 1930, p. 735.
15. Split-Housing Couplings Tested, *The Canadian Engineer*, Feb. 4, 1930.
16. The Purdue High-Pressure Boiler, by A. A. Potter, G. A. Hawkins, and H. L. Solberg, *Power*, Dec., 1931, p. 798.
17. Loeffler Steam-Tight Joint, *Engineering*, April 24, 1931, p. 539.
18. Suggestions as to the Adaptability of a Universal Standard Flange List for Marine Work, by Luther D. Lovekin, *Journal of the American Soc. Nav. Eng.* Vol. XVII, No. 3, p. 724-738.
19. Higher Pressures and Temperatures as They Affect the Design, Installation and Maintenance of Piping, by J. J. Harman, HEATING, PIPING AND AIR CONDITIONING, Feb., 1931, p. 109-111.
20. Testing High Pressure Steam Piping, by J. J. Harman, HEATING, PIPING AND AIR CONDITIONING, April, 1932, p. 253.
21. Chapter on Screws and Screw Fastenings. *Elements of Machine Design*, Kimball & Barr, p. 175, 1914 Edition.
22. Piping Handbook, by Walker and Crocker. McGraw-Hill Book Co., Inc.
23. Stresses in Bolts Due to Setting Up, *The Locomotive*, July, 1924, p. 77.
24. Analytical Study of Stresses in Bolts, by R. Fleming, *Engineering & Contracting*, March 24, 1920, p. 320.
25. Benson Boiler Joint, *Mechanical Engineering*, July, 1927, p. 808. Also *Power Plant Engineering*, July, 1927, p. 741.

[4] It has not been the custom, in articles of this type, to make any reference to catalogs. Nevertheless, such catalogs contain much useful technical information; they have been freely consulted.

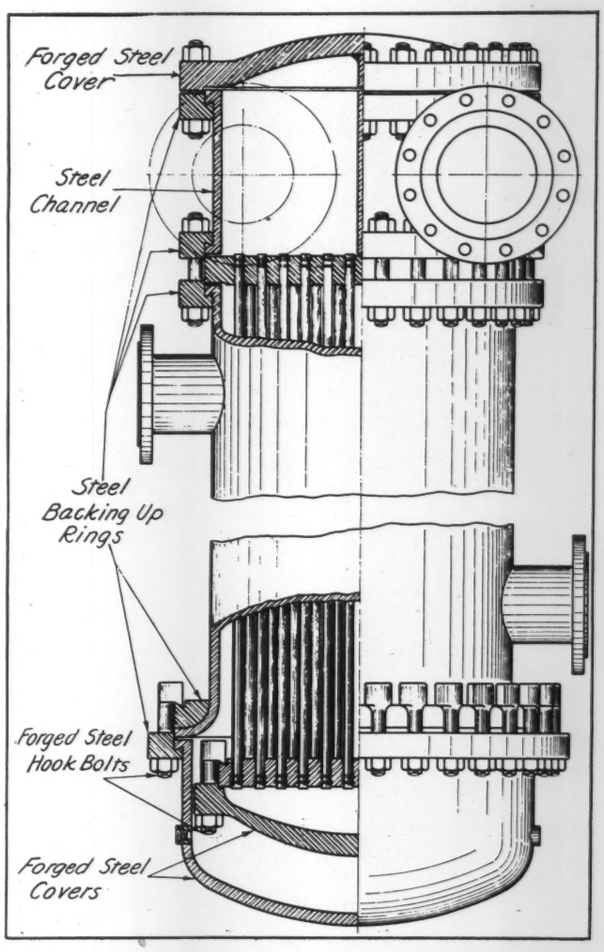


FIG. 6—RECENT TYPE OF HEAT EXCHANGER FOR PRESSURE OF 750 LB. PER SQ. IN. AND HIGHER. THE JOINT DETAILS ARE SHOWN IN FIGS. 7, 8 AND 9

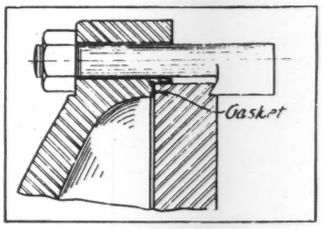


FIG. 7—FLOATING HEAD COVER JOINT FOR HEAT EXCHANGER SHOWN IN FIG. 6

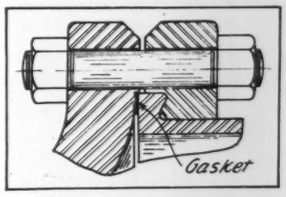


FIG. 8—CHANNEL COVER JOINT FOR HEAT EXCHANGER SHOWN IN FIG. 6

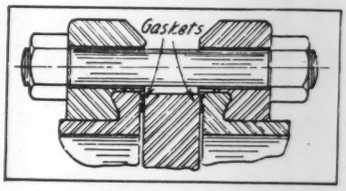


FIG. 9—FIXED TUBE SHEET JOINTS FOR HEAT EXCHANGER SHOWN IN FIG. 6

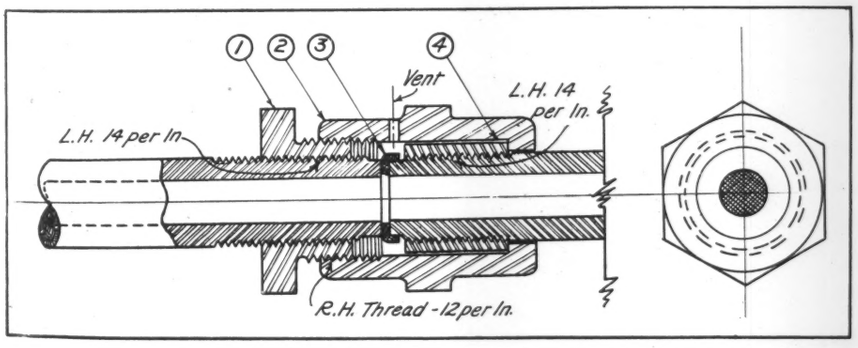


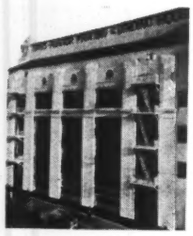
FIG. 5—UNION FOR SEAMLESS DRAWN TUBING. PRESSURE, 4,400 LB. PER SQ. IN.

REFRIGERATING EQUIPMENT, SHOWING RESTRICTED HEAD-ROOM AND COMPACT ARRANGEMENT

The indicator board on the left shows three colored lights for the guidance of the operating engineer. Amber top light indicates main supply fan on; amber light on and green light out indicates all fresh air dampers open and return dampers closed. Red second light on indicates outside wet bulb 60 F or more; run refrigerating machine as long as red light shows, regardless of other lights. Third green light indicates dew point in dehumidifier of 53 F or lower, main fresh air damper closed, and return air damper open. Gong rings to indicate that refrigerating machine should be started.

Benefits—Not Cost—Decided This Complete Air-Conditioning Plant

By . . . . . E. L. Ellingwood*



AN UNUSUAL amount of study was given to the design, construction and equipping of the new building[1] of the Times-Mirror Printing and Binding House, Los Angeles. Every departmental requirement was carefully analyzed and material, apparatus and equipment selected which would meet these requirements in a modern and efficient manner. Cost was not limited, the only qualifying condition being that all items of expense for equipment must be justified.

The Times-Mirror Printing and Binding House is one of the largest and oldest concerns in Los Angeles and does an extensive commercial printing, binding, lithographing and engraving business. Its new building is situated on Broadway, close to the Los Angeles civic center development. The building adjoins the property on Spring Street which will be occupied by the new monumental structure of the newspaper, the *Los Angeles Times*. The two organizations are under the same general ownership; this was taken into consideration in the design of the mechanical equipment for the Times-Mirror building. It was considered desirable to provide for the future consolidation of electric, steam and water service for both buildings, making it possible then to effect certain savings on account of centralization of equipment, low rates and high efficiency.

* Consulting engineer, Los Angeles, Calif.

[1] Gordon B. Kaufmann, Architect; Elliott Lee Ellingwood, Consulting Engineer.

Reasons for Providing Air Conditioning

Early in the preliminary development it was decided to install a complete air-conditioning system. The anticipated benefits were accurate register in color processing, dependable humidity control, no press delay due to weather effect on paper, elimination of static, rapid and uniform ink drying, and no odors from ink or varnish. The human comfort feature was also an important factor.

Entire Building Is Conditioned

The building consists of sub-basement and basement, each having 17,600 sq. ft. of floor area; the first, second and third floors, with 16,600 sq. ft. of floor area each; and the fourth floor of 6,250 sq. ft. containing the general offices. The total cubic content of the building is 1,325,000 cu. ft. The sub-basement and basement contain the telephone book presses and paper storage. The first floor is the job press room. The second floor contains the machine shop, engraving and etching departments, type foundry, etc. The third floor contains the composing room and the linotype and monotype rooms.

The entire building is air conditioned; the system is designed to maintain constant temperature and humidity conditions the year 'round. During the winter temperature is maintained at 70 F except the press rooms which are maintained at 75 F. During the summer the temperature throughout is maintained at 78 F; relative humidity is kept at 55 per cent the year 'round.

A central system conditions the air for the entire plant except for the general offices, which have a separate supply system. The dehumidified air for this system is supplied from the central dehumidifier through separate supply and recirculating fans. The 190-ton refrigeration machine is of the centrifugal automatic type.

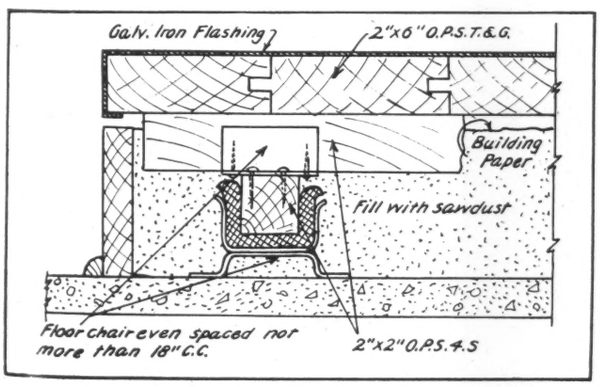
Constant Dew-Point Maintained

Humidity regulation is accomplished by means of hygrostats which control volume dampers and reheaters located in the air ducts on each floor. Constant dew-point temperature is maintained at the dehumidifier by regulating the temperature of the spray water. This is effected by controlling the quantity of cold water from the refrigeration machine during the summer and the amount of steam supplied to a coil located in the dehumidifier tank during the winter. This dew-point control also regulates the return and outside air dampers. Dew-point temperature maintained at the apparatus during the summer is 60 F and during the winter, 55 F. When the outside wet-bulb temperature is between these points all outside air is taken but the humidity is kept constant throughout the building and the dry-bulb temperature allowed to vary.

All heating is accomplished by the air supplied through the air-conditioning system. An oil-burning low-pressure cast-iron sectional boiler is installed, which will be removed when future connection is made to the large plant in the Times building.

Exhaust systems are provided for the manufacturing departments on the second floor and for the linotype, monotype and etching rooms. Toilet and locker rooms throughout the building are also equipped with mechanical exhaust. The duct system from the etching room is constructed of a special alloy and the fan is rubber-lined.

Success of the air-conditioning system in the printing and binding plant described here is largely due to the care with which the requirements were studied. Dew-point control is featured, but as the system is designed to keep humidity and dry-bulb temperatures in the comfort zone, particular study of air quantities and distribution was necessary.



SOUNDPROOF FAN AND MOTOR PLATFORM DETAIL

Installation of the Equipment

The refrigerating equipment is located in the basement of an adjoining building and is to be one of the three units comprising the larger plant in the new building. Condenser water is taken from the city mains and discharged to waste into the underground storm drain system. A large cooling tower will be erected on the new Times building to provide service for both buildings; in the meantime it is cheaper to waste the water.

Air supply ducts are exposed on the various ceilings and the air is distributed in accordance with the heat gain in different areas. The main ducts, each with separate heater and automatic volume damper, are located accordingly. Return risers are located on outside walls, connected together on the 3rd floor ceiling.

The following equipment is installed: Main supply fan, capacity 90,000 c.f.m.; cold water pump, 630 g.p.m.; office supply fan, capacity 14,600 c.f.m.; recirculating fan in paper storage room, capacity 7,500 c.f.m.; exhaust fan, capacity 15,000 c.f.m.; linotype and monotype room fan is a direct-connected unit having capacity of 3,000 c.f.m.; etching room exhaust fan, capacity 3,000 c.f.m.; refrigeration machine, capacity 190 tons, 200-hp. variable-speed motor.

The building is equipped with fixed metal sash and all frames are thoroughly grouted in. The construction is of reinforced concrete and is unusually tight; air leakage does not exceed 5 per cent of the supply fan delivery.

On the Job

. . . a department devoted to short, practical articles on the installation, operation and maintenance of air conditioning, heating and piping equipment . . . . . .

Stops Scale from Clogging Radiator

By W. H. Wilson

DURING the last heating season a complaint regarding insufficient heat in a plant was traced to a long battery of wall radiators (see sketch) located in an overhead skylight; the trouble was a stoppage caused by scale, rust and foreign matter in the radiator return outlet. Ordinarily this could have been taken care of easily by shutting off the steam, disconnecting the union connection of the thermostatic trap and clearing the return opening. However, in this case, there were shelves and tables on which textile fabrics of expensive quality were stored immediately below the radiator. All indications showed that the line of radiator sections was filled with water of condensation up to the feed valve. To disconnect the trap and attempt to remove the obstruction would have caused the material to be damaged by water before the trap could be reconnected.

Fortunately there was a compressed-air connection some distance away in another part of the building and sufficient hose was procured for an air pressure supply. The short pipe nipple, in the return line near the floor between the 45-deg. fittings was cut with a hack saw, removed and the air hose attached to the pipe leading to the radiator. Air pressure was then used to blow back through the return line, trap and radiators, clearing the obstruction. It was then possible to use two short nipples and a union to connect the return pipe, without enough water escaping to cause any material damage at that point. This put the heating system back in proper working order.

A condition of this kind can be remedied by using suitable return connections, as indicated in the inserts of the accompanying figure. The connection at the right is made by using a gate valve between the trap and the radiator to permit the trap to be disconnected and the return opening rodded out; a pail would receive all of the water escaping while the valve was being closed. The trap could then be connected, valve opened and the radiator put in operation.

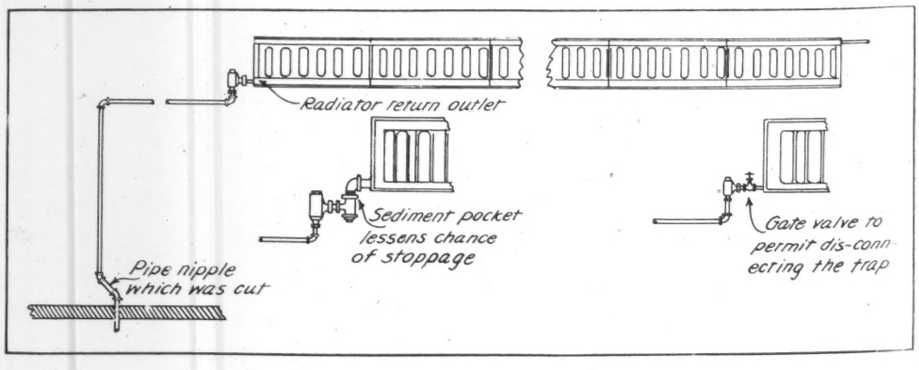
The connection shown at the left indicates another method where a sediment pocket the full size of the radiator opening is used, lessening the chance of stoppage in the return connection.

It is not to be expected that all radiators and heating units should require valves on the inlet side of the traps, but in special cases where the traps are not readily accessible and repair work may cause damage to building and contents, the expense of a valve or other suitable return connection would certainly be warranted insofar as maintenance work is concerned.

Change in Steam-Main Drain Prevents Trouble

PROPER drainage is most essential to the operation of high-and-low-pressure steam mains; careful attention should be given to the location of the traps and drains in order that they will be readily accessible; local conditions govern these locations. In many cases working room is limited, especially in tunnels, under floors and in pits. Trap installations must be made to conform to the room available.

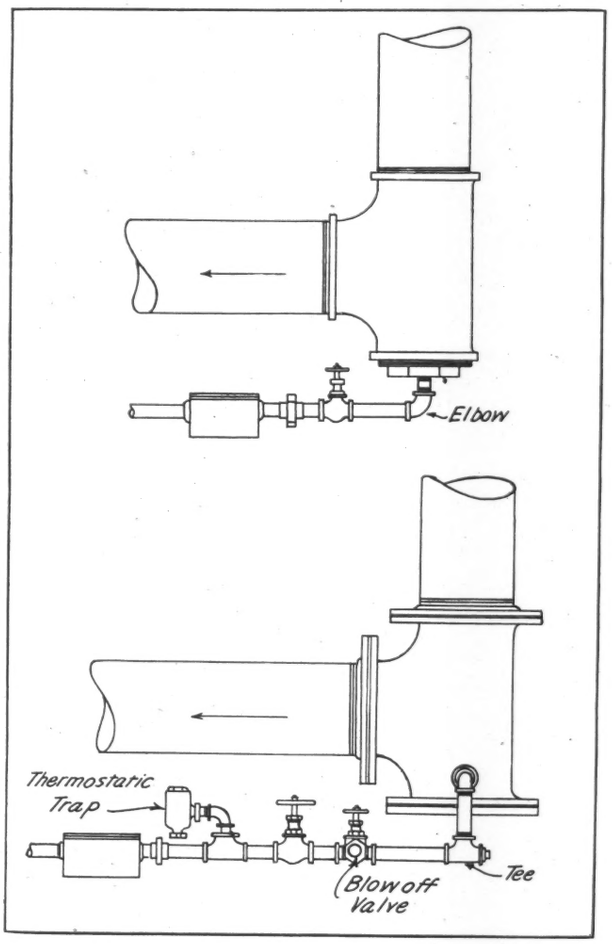
The drawing on the next page shows a drain for a large steam main that is taken from the bottom of


Radiator return outlet
Sediment pocket lessens chance of stoppage
Pipe nipple which was cut
Gate valve to permit dis-connecting the trap

WHEN THIS RADIATOR CLOGGED WITH SCALE, DIFFICULTY WAS EXPERIENCED AS EXPENSIVE TEXTILE MATERIALS WERE STORED BENEATH IT. THE RETURN CONNECTIONS ON RADIATORS IN SUCH LOCATIONS CAN BE MADE AS SHOWN IN THE INSERTS TO AID IN CLEANING OUT THE SCALE OR TO PREVENT STOPPAGE

the tee. Room was limited and a large reservoir or pocket to take care of slugs and large quanities of condensation could not be installed.

At one time when steam was turned on, water hammer occurred at this point; the main was taken out of service to investigate and a large piece of a pipe fitting was found in the tee, which had evidently gotten inside



When This Steam Main Was Drained as Shown at the Top, the Drainage Opening Became Stopped Up. The Connection Was Changed as Shown in the Bottom View to Prevent This

of the pipe during repair work and partially obstructed the drainage opening.

The bottom view shows a rearrangement of this connection. The drain connection is taken from the side of the tee, near the bottom instead of at the bottom to prevent its being obstructed as mentioned above. The blind flange of the large tee can be easily removed for cleaning and inspection.

The blowoff valve is provided to relieve the condensation when putting the main in service, or for relieving the pressure when repair work is required. These blowoff valves are a help to the maintenance man and often are an important safety measure. A tee on the drainage connection is used when in close quarters as it is easier to tighten a tee with the pipe wrench than an elbow when room for working is limited.

A thermostatic trap can be installed as shown to take care of the condensation in case the regular trap should fail to work; this has often been done to advantage by the writer. Thermostatic traps for this purpose should be of a type suited to the pressure and temperature of the steam and installed so that the condensation will ordinarily flow to the regular trap. The temperature of the steam will keep the thermostatic trap closed as long as the regular trap is working properly. With a free discharge to the atmosphere the thermostatic trap will open when an excess amount of condensation accumulates in the main and the discharge will usually give warning that the regular trap needs attention.

How to Paint Hot Surfaces

By Herbert Chase

TO assure a lasting paint coat for hot surfaces it is not only necessary to select the proper finish but to start with a surface that is clean and free from foreign matter. Paint applied over a rusty or an oily surface, for example, is quite certain to have poor adhesion. If applied over old paint which itself is beginning to crack, the chances of early failure of the new coat are materially increased. Rusty surfaces should be cleaned by sandpapering or sandblasting, or by the use of a chemical rust remover. The phosphoric-acid type of rust remover is excellent but with it as with other chemicals, the surface should be washed clean and dried before painting is done. Very light coatings of rust, as well as oil or grease, can be washed off with naphtha or other solvent materials.

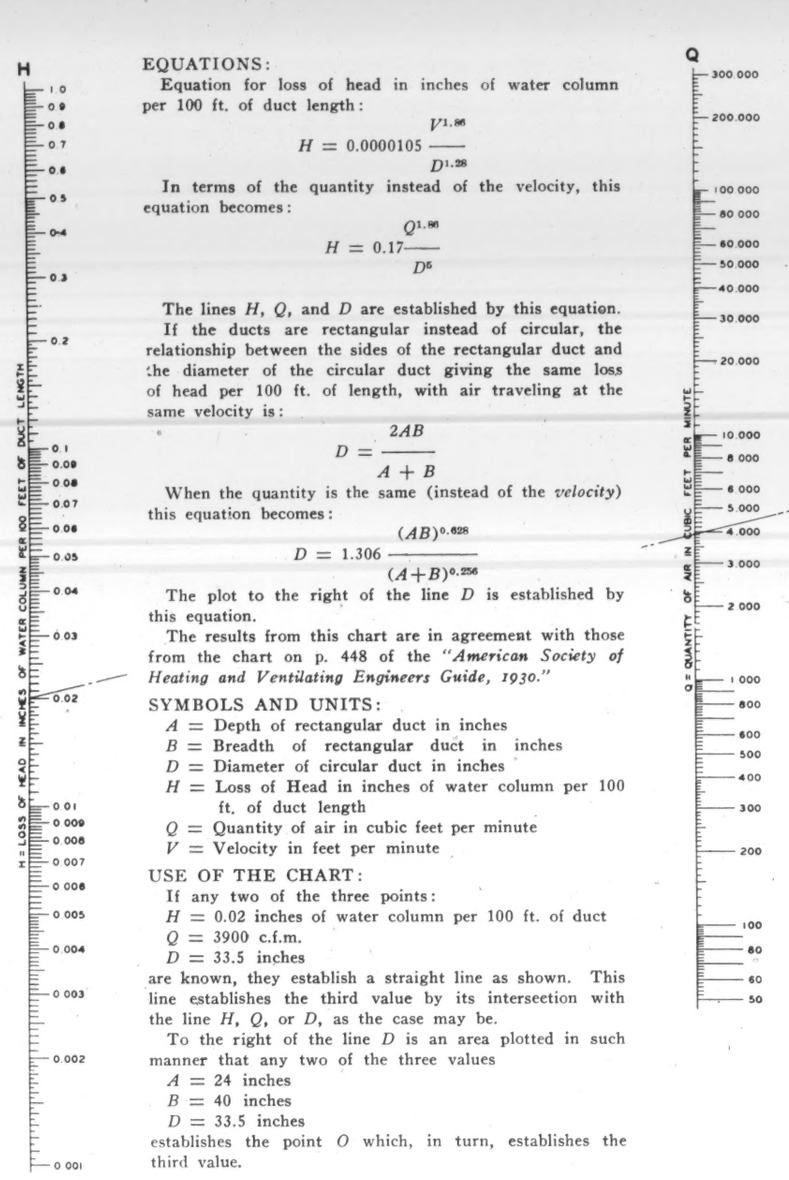
Cleaning Galvanized Surfaces

Galvanized surfaces are especially likely to shed paint films unless correctly treated. They may be cleaned, especially when new, with a mixture consisting of 14 parts of toluol, 4 parts of denatured alcohol and one part each of carbon tetrachloride and commercial muriatic acid (by volume) mixed in a glass bottle. This solution should not be allowed to drip or spatter on other surfaces because of its acid content. The acid is used to etch or roughen the zinc surface slightly and should be washed off as soon as the surface is dry.

Primer Promotes Adhesion

Some finishes adhere well without being preceded by a coat of primer, but for a first-class job one or two coats of a good primer seems to be essential. A primer for an iron or steel surface that is to be heated to a temperature not exceeding 350 F, and for galvanized iron or zinc, is one having 4 parts of metallic zinc dust and one part of zinc oxide (by weight) mixed in a vehicle containing 80 per cent of raw linseed oil, 15 per cent of thinner and 5 per cent of oil dryer. Four pounds of the pigment should be mixed in one pound of the vehicle. This type of pigment is especially suitable for use on heated surfaces because the zinc content helps to keep the vehicle distensible, which is important in the case of films to be subjected to heat; it also promotes adhesion and inhibits rust.

For a three-coat job a flat finish fairly high in oil with



EQUATIONS:

Equation for loss of head in inches of water column per 100 ft. of duct length:

$$H = 0.0000105 \frac{V^{1.86}}{D^{1.28}}$$

In terms of the quantity instead of the velocity, this equation becomes:

$$H = 0.17 \frac{Q^{1.86}}{D^{5}}$$

The lines H, Q, and D are established by this equation.

If the ducts are rectangular instead of circular, the relationship between the sides of the rectangular duct and the diameter of the circular duct giving the same loss of head per 100 ft. of length, with air traveling at the same velocity is:

$$D = \frac{2AB}{A + B}$$

When the quantity is the same (instead of the *velocity*) this equation becomes:

$$D = 1.306 \frac{(AB)^{0.628}}{(A+B)^{0.256}}$$

The plot to the right of the line D is established by this equation.

The results from this chart are in agreement with those from the chart on p. 448 of the *"American Society of Heating and Ventilating Engineers Guide, 1930."*

SYMBOLS AND UNITS:

A = Depth of rectangular duct in inches
B = Breadth of rectangular duct in inches
D = Diameter of circular duct in inches
H = Loss of Head in inches of water column per 100 ft. of duct length
Q = Quantity of air in cubic feet per minute
V = Velocity in feet per minute

USE OF THE CHART:

If any two of the three points:
H = 0.02 inches of water column per 100 ft. of duct
Q = 3900 c.f.m.
D = 33.5 inches
are known, they establish a straight line as shown. This line establishes the third value by its interseetion with the line H, Q, or D, as the case may be.

To the right of the line D is an area plotted in such manner that any two of the three values
A = 24 inches
B = 40 inches
D = 33.5 inches
establishes the point O which, in turn, establishes the third value.

CHART FOR AIR FLOW IN DUCTS OF AID TO THE MAINTENANCE MAN

a large volume of pigment should be used for the second coat, but two coats are enough for most work. Several types of final coat give good results whether two or three coats are employed; among them are those made from the modern glyptol enamels, especially if white or a light color is desired, as discoloration is likely to be minimized. If white is used, one with a high percentage of titanium oxide pigment will retain its white color satisfactorily. Most glyptol enamels are made for spray application, but they can be had for application with a brush if so ordered.

In the case of hot pipes that have insulating jackets containing asbestos or similar materials, a primer or sealer of the spar-varnish type containing just enough pigment to show where it has been applied may be used for the first coat. It should be followed by a flat coat high in oil and containing plenty of pigment and by the same final coat mentioned above for metal.

Effect of Paint on Heat Emission

Tests made at the *University of Illinois* indicate that paints have little effect upon the heat dissipated by convection but do affect to some extent the heat radiated. Neither convection nor radiation is materially affected by the undercoat or coats; such differences as occur are the result of the final coat. Finely ground pigments have about the same radiation constant, but flake metal finishes have a relatively low radiating effectiveness. The following table giving the results of comparative tests of radiators is reported by Prof. William H. Severns of the Department of Mechanical Engineering, *University of Illinois:*

Finish	Coefficient of Heat Transmission. Btu	Relative Heating Value. Per Cent
One coat dull black paint	1.76	100.0
One coat aluminum bronze	1.60	90.8
Gray paint dipped	1.78	101.1
Bare iron, foundry finish	1.77	100.5

Chart Helps Duct Changes

By George T. Condron*

THE chart shown here for low-pressure air flow in ducts has been of considerable value to the writer, as it saves perhaps 90 per cent of the time which would be required in making calculations using no chart at all and is believed to be a simplification of charts now available, particularly when dealing with rectangular ducts. Although loss in straight runs is only part of the total loss of head, it is a necessary step in determining this loss which must be known in order to determine the sizes for blowers and motors.

The man in the field will find the plotted area to the right of the vertical line D of value in determining the dimensions to be used in cases where unforeseen conditions require a change from the original duct dimensions. By determining the new dimension so as to have the same value for D (equivalent diameter), the friction loss per unit length of duct will remain unchanged.

The chart was prepared for the determination of the loss of head when air flows through straight runs of sheet-metal duct work. It is based on the following mathematical relations:

$$H = 0.0000105 \frac{V^{1.86}}{D^{1.28}} \quad \ldots\ldots (1)$$

$$D = \frac{2AB}{A+B} \quad \ldots\ldots (2)$$

Equation *1* is the basis of a chart that is printed in the *"American Society of Heating and Ventilating Engineers Guide,"* and Equation *2* is from the same authority.

Chart Is Based on C.f.m.

Since it was desired to use the quantity of air flowing in the duct, rather than the velocity of flow, as the quantity is usually one of the first known factors, it was necessary to convert these equations to a quantity basis:

$$H = 0.17 \frac{Q^{1.86}}{D^{5}}$$

$$D = 1.306 \frac{(AB)^{0.625}}{(A+B)^{0.250}}$$

A = depth of rectangular duct in inches
B = breadth of rectangular duct in inches
D = diameter of circular duct in inches
H = loss of head in inches of water column per 100 ft. of duct length
Q = quantity of air in cubic feet per minute
V = velocity in feet per minute

Using the Chart

In solving cases involving circular ducts, there are three factors: Quantity, Diameter, and Loss of Head. If any two of these factors are known, they establish points on the corresponding vertical lines. These two points will establish a straight line which, in turn, will establish the value of the third factor by its point of intersection with the third vertical line. This is illustrated by the dot-dash line on the chart, established by the points:

$D = 33.5$ in.
$Q = 3900$ c.f.m.

This dot-dash line intersects the line H at the point:

$H = 0.02$ inches of water column

This is the loss of head resulting from the assumed flow conditions.

Solution of Rectangular Ducts

The solution in a case where the duct is rectangular is the same as above, except that the equivalent diameter must be determined from the depth and breadth of the rectangle, or *vice versa*. This is done on the plotted area to the right of the vertical line D. In this area any two of the three factors (diameter, depth, and breadth) will establish a point, which will, in turn, establish the value of the third factor. Such a point is shown at O, established by:

$A = 24$ in.
$B = 40$ in.

This point establishes:

$D = 33.5$ in.

It will be noted that the sectional area of rectangular ducts which have the same equivalent diameter decreases as the ratio of A to B approaches unity, the square duct.

* Mechanical engineer, Condron & Post, Chicago, Ill.

Interest in Air Conditioning Is World-Wide

THAT interest in air conditioning for human comfort is not confined to the United States and Europe is demonstrated by two letters which have been received during the past month, one from a Brazilian scientist who wishes to be of aid in explaining air conditioning to the people of his country; the other letter is from a firm desiring helpful data to be used in connection with the installation of ice-cooled air-conditioning systems in South African theaters.

Believing these letters will be of interest to American engineers and others concerned with air conditioning they are published here.

South African Firm Wants Information

249 Main St.,
Johannesburg, South Africa,
June 15, 1932.

The *Editor*,
HEATING, PIPING AND AIR CONDITIONING,
1900 Prairie Avenue,
Chicago, Ill., U. S. A.

Dear Sir:

On pages 352-353 of the May issue of HEATING, PIPING AND AIR CONDITIONING, is described how a small theater solves air conditioning problems with ice.

We have in the past air conditioned a large number of small theaters in this part of the world where neither heating nor cooling is necessary, but merely air movement in order to produce certain required kata conditions.

With this we have been very successful but we have been looking around for an installation such as you describe in your paper for use in our sub-tropical localities. In these localities humidity is high—likewise temperatures. It is, therefore, necessary to use dehumidifying equipment.

Would you be good enough to put us into touch with one or more concerns in your country who manufacture the necessary apparatus and who are prepared to provide us with the necessary information on air conditioning small theaters holding say 600 and alternatively 1,000 people.

The shade temperatures we have to contend with range from 80/100 F and under these conditions the humidity ranges between 80/90.

We would at the same time like to know what the cost of ice would be, there being two performances per day, namely from 2:30 to 5:30 and from 7 o'clock to 11 o'clock, basing your figures at say $7 per ton for ice.

We have been regular subscribers to your paper for a number of years.

We have been on the look out for a system such as you describe on page 352 of the May issue for a long time, and it would appear that the idea described is very suitable and apparently economical.

Trusting we may have the pleasure of hearing from you at your earliest convenience in this connection we remain,

Yours very truly,
G. H. LANGLER & CO., LTD.

Brazilian Scientist Wants Air-Conditioning Data

Rio de Janeiro, Brazil,
72 Rua Alberto de Campos,
June 20, 1932.

Editor, HEATING, PIPING AND AIR CONDITIONING,
1900 Prairie Avenue,
Chicago, Ill.

Dear Sir:

I wish to conduct an intensive educational campaign on air conditioning in Brazil. As a meteorologist, the subject is of great interest to me. I am the retired Director of the Brazilian Meteorological Service and a Fellow of the American Meteorological Society (its Councillor up to 1933).

I don't mean to establish commercial connections, although I would be glad to help indirectly the introduction of air conditioning to our country, especially in homes and public enclosures of all kinds (theaters, lecture halls, etc.)

I intend to write popular and scientific articles as well as to give lectures on the subject, and am in need of the following:

1. Reliable scientific data.
2. Technical data—information on machinery, methods, etc.
3. Photographs of installations and buildings; if possible, lecture slides which would be returned.
4. Commercial data—approximate prices of different types of plants (c.i.f. Rio if possible) and probable expense of their installation; taking as typical cases, say, movie theaters for 1,000 people, and homes with the ordinary number of rooms for an average family.
5. Abstracts of scientific papers and bibliography of air conditioning in the United States.

I feel that I am asking for the information I need in a very superficial manner, but undoubtedly interested engineers will know exactly what they should supply to facilitate my task.

I am a constant reader of HEATING, PIPING AND AIR CONDITIONING and will obtain much information from your articles.

Could you put me in contact with the more important air conditioning concerns of the United States? I shall be pleased if you will send them a copy of this letter, with the strict injunction that I am not considering any commercial benefit in this matter, although I may give assistance in the commercial aspect, of course without remuneration. My hope is to act as a man of science in a problem that I consider of enormous importance in a hot and damp country like Brazil (at least a great part of it is hot and humid). I wish to be instrumental in spreading knowledge of air conditioning both from the scientific and practical points of view, and for this I need the data mentioned above.

I hope you will find it possible to assist me; trusting to hear from you at an early date and thanking you in anticipation, I am

Yours sincerely
J. de Sampaio Ferraz

District Heating Book Issued

Aimed to provide an authoritative and complete manual of practice for the use of those actively engaged in district heating is the new "Handbook of the National District Heating Association" recently published. The material included in this work is drawn from the papers and reports in the Association's proceedings and from the files of many operating companies.

The technical section of the book consists of 473 pages and includes numerous illustrations, charts and tables. In addition there is a section of approximately 50 pages devoted to equipment.

The handbook is divided into the following chapters: Growth and present status of district heating; general data; building heating methods; customers' miscellaneous equipment; steam distribution; district heating plants; steam meters and metering; hot-water heating; corrosion in steam-heating systems; rates; sales activities; and the economical use of steam.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

1895

AUGUST 1932

Material in this Section prepared by Publication Committee: F. D. Mensing, *Chairman;* E. O. Eastwood and F. E. Giesecke A. V. Hutchinson, Manager of Publications

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ILLINOIS

Headquarters, Chicago

Meets: Second Monday in Month

President, J. J. AEBERLY
704 City Hall

Secretary, C. W. DELAND
211 N. Desplaines St.

KANSAS CITY

Headquarters, Kansas City, Mo.

Meets: Second Monday in Month

President, J. M. ARTHUR
1330 Grand Ave.

Secretary, D. D. ZINK
2445 Charlotte St.

MASSACHUSETTS

Headquarters, Boston

Meets: First Monday in Month

President, F. R. ELLIS
131 Beacon St., Hyde Park

Secretary, LESLIE CLOUGH
Box 34, Weymouth, Mass.

MICHIGAN

Headquarters, Detroit

Meets: First Monday after the 10th of the Month

President, L. L. MCCONACHIE
1415 Harvard Rd.

Secretary, G. D. WINANS
2000 Second Ave.

WESTERN MICHIGAN

Headquarters, Grand Rapids

Meets: Second Monday in Month

President, D. L. TAZE,
604 Building and Loan Bldg.

Secretary, P. O. WIERENGA,
231 Brown St., S. E.

MINNESOTA

Headquarters, Minneapolis

Meets: Second Monday in Month

President, W. F. UHL
4716 Lyndale Ave.

Secretary, C. E. LEWIS,
829 2nd Ave.

NEW YORK

Headquarters, New York

Meets: Third Monday in Month

President, L. T. M. RALSTON
Chrysler Bldg.

Secretary, T. W. REYNOLDS
25 E. 26th St.

WESTERN NEW YORK

Headquarters, Buffalo

Meets: Second Monday in Month

President, M. C. BEMAN
374 Delaware Ave.

Secretary, W. E. VOISINET
304 Curtiss Bldg.

ONTARIO

Headquarters, Toronto, Can.

Meets: First Monday Every Other Month

President, J. S. WOOD
72 Queen St., E.

Secretary, H. R. ROTH
1104 Bay St.

PACIFIC NORTHWEST

Headquarters, Seattle, Wash.

Meets: Second Thursday in Month

President, C. F. TWIST
967 Thomas St.

Secretary, S. D. PETERSON
473 Colman Bldg.

PHILADELPHIA

Headquarters, Philadelphia

Meets: Second Thursday in Month

President, L. C. DAVIDSON
810 Land Title Bldg.

Secretary, W. P. CULBERT
2019 Rittenhouse St.

PITTSBURGH

Headquarters, Pittsburgh

Meets: First Monday in Month

President, R. B. STANGER
Empire Bldg.

Secretary, J. L. BLACKSHAW
3728 Dawson St.

ST. LOUIS

Headquarters, St. Louis

Meets: First Wednesday in Month

President, J. M. FOSTER
4526 Olive St.

Secretary, C. R. DAVIS
2328 Locust St.

SOUTHERN CALIFORNIA

Headquarters, Los Angeles

Meets: First Tuesday after the 10th of the Month

President, F. R. WINCH
1031 S. Broadway

Secretary, E. H. KENDALL
1224 S. San Pedro St.

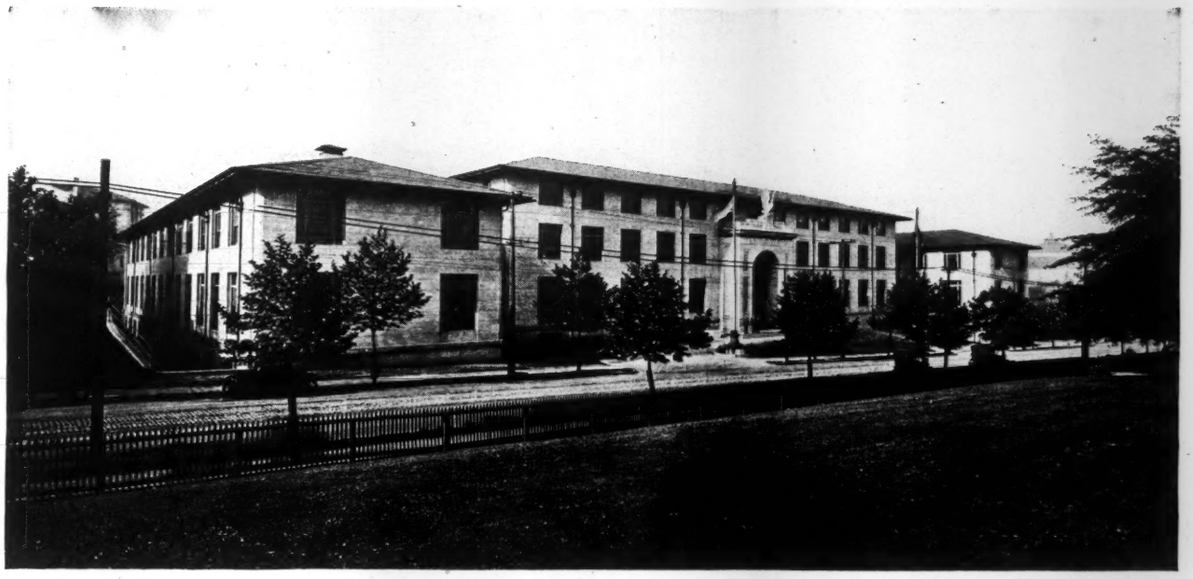
WISCONSIN

Headquarters, Milwaukee

Meets: Third Monday in Month

President, E. A. JONES
339 S. Second St.

Secretary, H. F. HAUPT
170 Beaumont Ave.



PITTSBURGH EXPERIMENT STATION OF THE U. S. BUREAU OF MINES WHERE THE RESEARCH LABORATORY OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS IS LOCATED

Carbon Monoxide Distribution in Relation to the Ventilation of an Underground Ramp Garage

By F. C. Houghten[1] (*MEMBER*) and Paul McDermott[2] (*NON-MEMBER*), Pittsburgh, Pa.

THE activities of the A. S. H. V. E. Research Laboratory have been identified with garage ventilation and its effect on removing carbon monoxide hazards since 1928 when a Technical Advisory Committee on the subject was appointed. During the fall of 1931 the Committee on Research authorized a study by the Laboratory in a small single-room, window-ventilated garage and in an underground ramp garage. Details concerning the purpose of the study and the results of the investigation in the single-room, window-ventilated, Sheraden Garage were published in another report.[3] The results of the study in the underground ramp garage in the basement of the Grant Building are the basis of this paper.

[1] Director, Research Laboratory, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

[2] Research Engineer, Research Laboratory, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

[3] Carbon Monoxide Distribution in Relation to the Ventilation of a One-Floor Garage, by F. C. Houghten and Paul McDermott (*Heating, Piping and Air Conditioning*, July 1932).

Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Milwaukee, Wis., June 1932.

Grant Building and Garage

The Grant Building, Fig. 1, is a modern 40-story office building of the set-back skyscraper type built in 1926. A plan of the basement of the building is shown in Fig. 2. It is 48½ ft in depth below the first floor of the building, and is divided into two parts. The five-story ramp garage in which the study was made is the west portion, 171 ft 9 in. by 91 ft 4 in. in area. The east portion of the basement, having a floor area of 5,630 sq ft, is partitioned off from the garage area by an unplastered hollow tile partition, and contains storage space and fireproof vaults for the office tenants of the building, a laundry and other service rooms, heating and other mechanical equipment for the building, and the garage ventilating plant. The division of this part of the basement into floors is somewhat irregular, but the main portion of the area is divided into five floors below the first floor of the building.

Fig. 3 is a typical floor plan of the garage, showing location of the ramps, the division of the floors into

TABLE 1—DIMENSION OF VERTICAL SUPPLY AND EXHAUST DUCTS

FLOOR	SUPPLY DUCT DIMENSIONS								EXHAUST DUCT DIMENSIONS			
	1	2 & 3	4	5	6 & 9	7 & 8	10	11	1 & 6	2	3 & 4	5
1	17x24	18x18	0	0	0	18x13	0	18x18	11x20	0	24x54	21x27
2	24x35	18x26	24x35	18x 52	24x21	18x26	18x18	18x28	18x22	21x30	33x54	21x42
3	24x51	18x39	24x51	18x 76	24x42	18x39	18x36	18x42	24x24	21x40	44x54	21x56
4	24x68	18x53	24x68	18x104	24x63	18x53	18x56	18x54	27x30	21x50	54x54	21x70
5	24x84	18x64	24x84	18x121	24x84	18x64	18x72	18x72	31x33	21x60	54x66	21x84

the east and west levels, and the vertical ventilating ducts. Fig. 4 is a vertical section of the garage, showing the floor levels, arrangement of ramps and other characteristic features. The floors are numbered from the top down as 1-east, 1-west, etc., to 5-east and 5-west. In presenting data in this report, these are frequently referred to as *1E, 1W,* etc., to *5E* and *5W* respectively. In other places these are referred to as the first and fifth floors or levels.

The ventilation of the garage includes independent supply and exhaust systems. The supply side of the ventilating system consists of two intake fans located on the fifth level which take air from a 4 ft by 40 ft 8 in. concrete-lined, downcast shaft leading down from a grating in the sidewalk at the south end of the building. The incoming air passes through a 9 ft by 25 ft opening

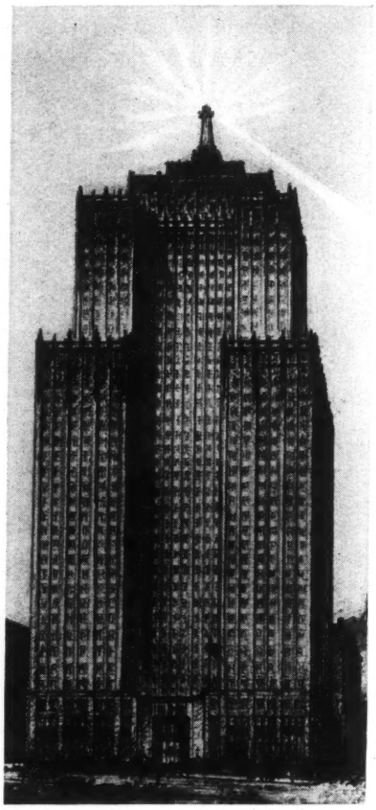


FIG. 1 — GRANT BUILDING, PITTSBURGH, PENNSYLVANIA

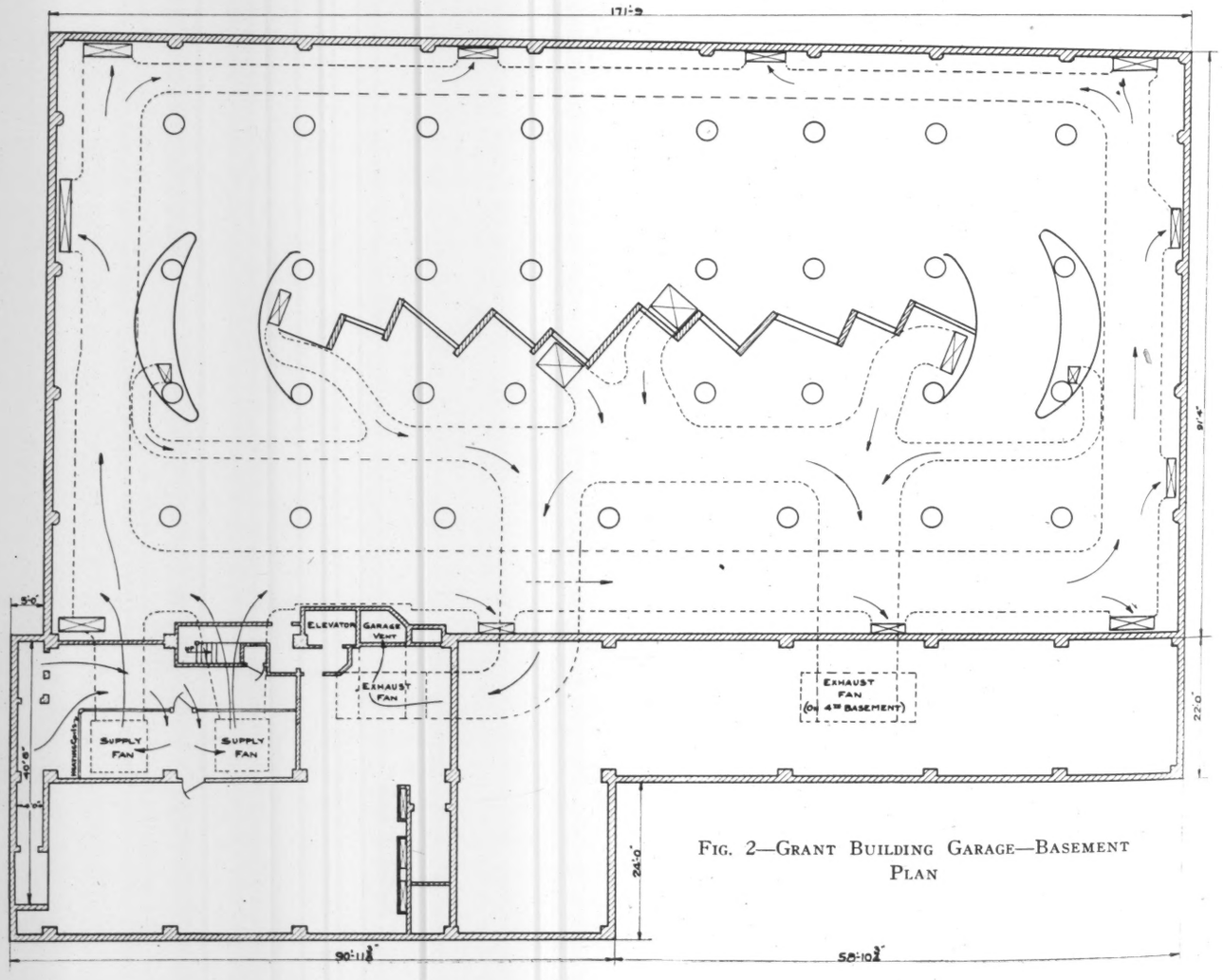


FIG. 2—GRANT BUILDING GARAGE—BASEMENT PLAN

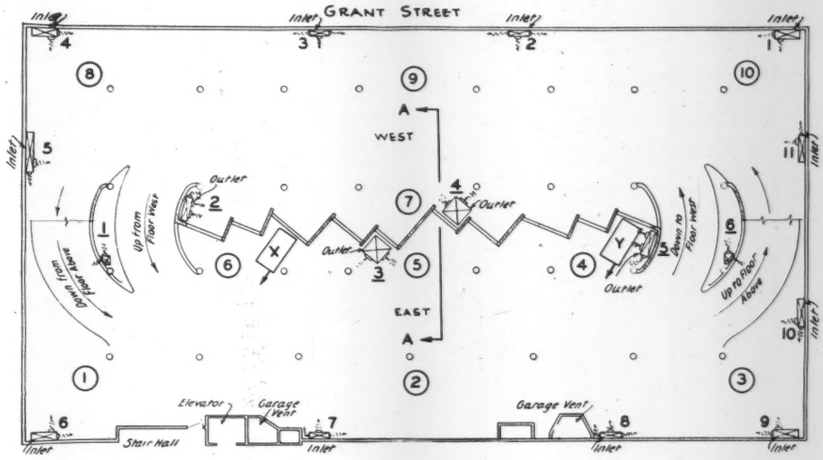


FIG. 3—TYPICAL FLOOR—GRANT BUILDING GARAGE
1 etc. to 11—Supply Risers (Around Wall)
1 etc. to 6—Exhaust Ducts (Center Line)
① etc. to ⑩—Sampling Stations
X and *Y*—Location Idling Cars

at the bottom of this shaft which is fitted with two sections of adjustable louvers, 9 ft by 7 ft and 9 ft by 18 ft, respectively. It then passes through tempering coils into a room from which it enters either of the two supply fans. The two supply fans deliver the incoming air to a common set of concrete ducts, distributing it to the bottom of the 11 sheet metal supply risers running up to a point 18 in. below the ceiling of the first floor. These risers supply air at both ceiling and floor at the 11 points indicated in Fig. 3 on each floor level. During the heating season the supply air is tempered so that it enters the fans at approximately 55 F. The temperature in the garage is usually from 2 to 5 deg higher than that of the air entering the fans.

The exhaust system consists of six downcast ducts, running from near the ceiling of the first or upper floor to a system of concrete ducts below the bottom or fifth floor of the garage, from whence the exhaust air is carried to a common suction chamber from which it enters the two exhaust fans, one located on the fifth level and the other on the fourth level. Each exhaust fan discharges the vitiated air through a separate sheet metal lined air shaft, which runs from the fan up through the building to a setback on the thirty-fourth floor. The arrangement of the ventilating system allows great flexibility of operation. Each supply or exhaust fan may be operated independently, each functioning on all sections of the garage. All four fans are equipped with variable speed control.

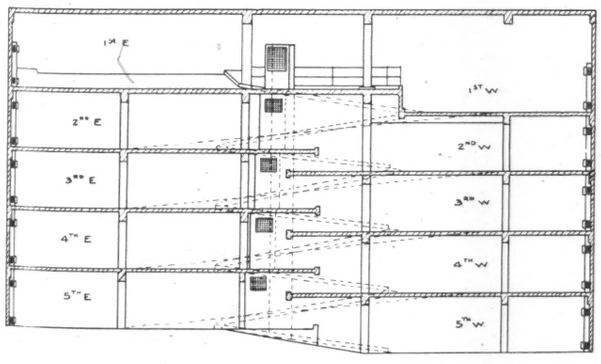


FIG. 4—VERTICAL SECTION *AA* OF GRANT BUILDING GARAGE SHOWING FLOORS AND RAMPS

At low speed with the small set of adjustable intake louvers open, each of the two supply fans deliver 19,500 cfm when both are in operation, and 21,100 cfm when both are in operation with all intake louvers open. At high speed they each deliver 30,400 cfm with the one set of louvers open, and 39,600 cfm with all intake louvers open. Each of the two exhaust fans handle 12,200 cfm at low speed with both fans operating. For both fans operating at high speed they each handle 18,400 cfm.

Fig. 3 shows the location of the supply risers supplying air to the different levels of the garage, and the downcast ducts exhausting air from the different levels. The dimensions of the vertical supply and exhaust ducts are given for each floor in Table 1. The outlet and inlet sizes and their locations for each floor are given in Table 2.

The garage, which has a parking capacity of 237 cars, is of the usual ramp type, the floors on the east and on the west half of the garage being staggered by one-half story. Each floor, east or west, provides a roadway in the center, with angle parking at either side. Moving cars, ascending or descending, use this roadway. At either end of the garage, ramps lead from any roadway or floor level to the floors above and below. All cars, either ascending or descending the ramps, pass northward in the east half of the garage and southward in the west half.

All floors are interconnected through the ramps and throughout the center line of the garage where the staggered floors meet. There are also four vertical openings throughout the height of the garage, two near the ramps at either end. This interconnection of floors allows free air movement throughout the garage, thus complicating any study of the ventilating effects.

The garage is essentially for the convenience of the office tenants of the Grant Building, but when not filled by the tenants of the building it is opened to the public. In normal operation, the maximum number of cars enter between 8:30 and 10:00 a.m. when the rate of entering cars reaches two to three per minute. The movement of cars remains a minimum throughout the day, and again rises to a peak between 4:30 and 6:00 p.m. when the cars are driven out. During the period of this study the garage was operated at about 75 per cent capacity.

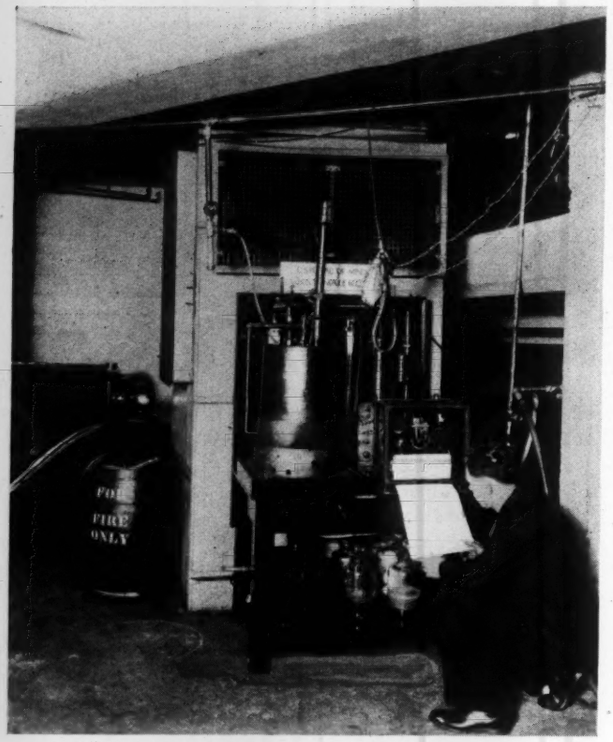


FIG. 5—U. S. BUREAU OF MINES CARBON MONOXIDE RECORDER SET UP IN GRANT BUILDING GARAGE

Method of Attack

The study resolved itself into a series of surveys designed to give the concentration of carbon monoxide within the garage, and the variation in this concentration from point to point, depending upon the type and amount of ventilation and the car operation.

Two methods of determining the concentration of carbon monoxide in the air were available for this study, namely, the pyrotannic acid method described in the companion report[3] and the Bureau of Mines Carbon Monoxide Recorder, which is sensitive to concentrations of one part per million. The recorder, a complicated instrument developed by the U. S. Bureau of Mines as reported by S. H. Katz and others,[4] Fig. 5, is not easily moved, and hence, in making a garage survey with it, the instrument must be set up at a convenient place, and samples from the various points piped to it.

A considerable time lag is experienced in the use of the recorder, making it necessary to sample a given location for at least 10 min in order to get a true indication of the carbon monoxide concentration. In making the study in the Grant Building Garage, the recorder was located on the third floor east near the center of the building. A ¾-in. pipe was run from the instrument throughout the height of the garage with valved outlets at each floor east and west. A rubber hose could be attached at any one of these outlets, and its nozzle carried to any point on that floor in making the survey. While this method of analysis has the advantage of being extremely sensitive, it also has the disadvantage of not being adaptable to a rapid survey of an entire floor. A combination of the use of the recorder and the pyrotannic acid method was found convenient and valuable. The carbon monoxide recorder was used as a control to determine variation in concentration at one point with time, or to determine variations at a few points. The wider surveys of the garage were made by taking samples for the pyrotannic acid method of analysis when the recorder showed that the desired condition existed.

Surveys Made in the Garage

Eighteen surveys were made in the garage, representing different conditions of ventilation or car operation.

TABLE 2—OUTLET AND INLET SIZES AND THEIR LOCATIONS FOR EACH FLOOR

Supply Duct Number	Floor 1			Floors 2, 3, 4, 5		
	Number of Outlets	Height and Width of Outlets in Inches	Height Floor to Center	Number of Outlets	Height and Width of Outlets in Inches	Height Floor to Center
1	2	13 x 14	90	2	12 x 13	86
	2	13 x 14	12	2	12 x 13	12
2, 3, 7, 8[a]	3	8 x 10	82	3	8 x 10	88
	3	8 x 10	10	3	8 x 10	10
4				2	12 x 13	86
				2	12 x 13	12
5	2	14 x 24	30	2	12 x 20	90
				2	12 x 20	12
6 and 9				2	12 x 18	90
				2	12 x 18	12
10				2	12 x 14	90
				2	12 x 14	15
11	2	10 x 12	101	2	10 x 12	77
	2	10 x 12	6	2	10 x 12	11

Exhaust Duct Number	Floor 1			Floors 2, 3, 4, 5		
	Number of Outlets	Height and Width of Outlets in Inches	Height Floor to Center	Number of Outlets	Height and Width of Outlets in Inches	Height Floor to Center
1 and 6[a]	1	17 x 20	80	1	10 x 18	89
	1	12 x 18	78	1	10 x 10	89
2				2	12 x 18	134
				2	12 x 18	24
3 and 4	1	48 x 48	60	1	24 x 48	84
	1	48 x 24	60	1	48 x 24	72
5	2	36 x 13	66	2	26 x 18	75
	1	36 x 25	66	1	13 x 18	75

[a] Supply duct No. 8 has an extra outlet 8x10 in. at 60 in. from floor on 4th floor. Exhaust duct No. 1 has an extra outlet 10x18 in. at 80 in. from floor on 2nd floor.

[3] Carbon Monoxide Distribution in Relation to the Ventilation of a One-Floor Garage, by F. C. Houghten and Paul McDermott (*Heating, Piping and Air Conditioning*, July 1932).

[4] *U. S. Bureau of Mines Technical Paper*, 355, by Katz, Reynolds, Frevert and Bloomfield (1926).

The conditions for the separate surveys are presented, together with the results of the analyses and conclusions drawn from them.

Survey 2 of Entire Garage by Recorder Method March 22, 1932, 10:57 a.m. to 5:11 p.m.

For this survey the supply and exhaust fans were operated at low speed throughout the day, while the recorder sampled air from twelve stations throughout the garage. At each station samples were taken at both ceiling and floor. Sampling at some of the stations was repeated. As stated the recorder shows considerable lag in indicating carbon monoxide concentration for any given air condition. Sampling for a period of 10 min gave at least 7 min during which the instrument record showed the true percentage of carbon monoxide at the point studied. The carbon monoxide concentrations found for all stations in this survey throughout the day are shown in Table 3.

The station numbers and floors used in this table are indicated in Figs. 3 and 4 respectively. The time at which sampling at any station was started is indicated in the first of the three columns under the station; the second and third columns under the stations give the concentrations found at the ceiling and floor of the station, the ceiling being sampled first.

This survey shows concentrations throughout the garage varying from 0.113 to 0.315 parts of carbon monoxide per 10,000 parts of air. During the day studied frequent observations were made of the carbon monoxide concentration at the single control point, 5. Fig. 6 is a log of the recorder reading during the day while sampling at the various locations indicated and at the control point. The evening peak is shown between 5:00 and 6:30 p.m. All of this peak is not included in the foregoing survey.

Little or no consistent variation in carbon monoxide concentration throughout the garage is shown, excepting that due to the time of day at which the analysis was made. There is, however, a fairly consistent higher percentage shown at the ceiling, the average of all ceiling observations at all stations during the entire day giving a concentration of 0.188 parts in 10,000, and the floor an average of 0.178 parts in 10,000. Eighty-eight cars passed through, entered, or left the floor on which samples were taken during the period of the survey, or an average of 14.6 per hour. Bearing in mind that concentrations of 1.0 part in 10,000 may be considered permissible over an extended period of time, and that concentrations up to 2.0 parts in 10,000 are not serious for short intervals, it will be noted that even with the ventilating system running at low speed the condition is well below the permissible value of 1.0 part in 10,000, excepting for a short interval in the evening rush period, when it went above 1.0 part for 40 min, reaching a maximum of 1.3 parts in 10,000 for a much shorter time.

In some of the later tests steps were taken to increase the concentration in order to obtain data on conditions of higher concentration. In considering these later cases, it should be kept distinctly in mind that they were artificial conditions set up for the purpose of the study, and were by no means characteristic of the garage.

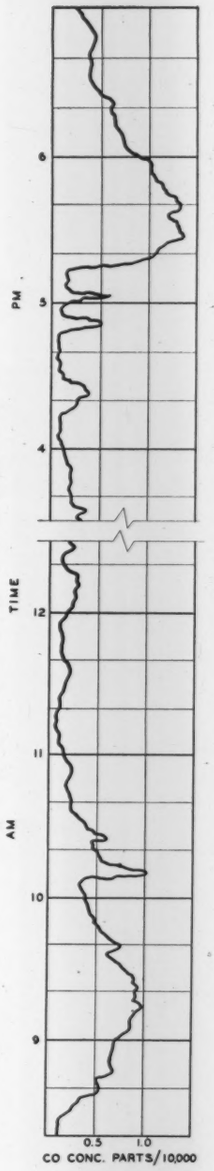


FIG. 6—LOG FROM RECORDER RECORD MARCH 22, 1932. FANS RUNNING SLOW SPEED. OTHER OPERATING CONDITIONS NORMAL

Survey 3 of Floor 3E by Recorder Method, March 23, 1932, 10:23 a.m. to 5:32 p.m.

This survey was limited to Floor *3E*. Both supply and exhaust fans were operated at low speed. All of the air supply openings at the ceiling and all the exhaust openings at the floor on *3E* were closed, allowing air to be supplied at the floor line and to be exhausted at the ceiling.

Throughout the day samples were taken at five stations, *1, 2, 3, 4,* and *7*. The results of these analyses are given in Table 3. The average for all samples taken at the ceiling in this survey gives a concentration of 0.246; the average for the floor is 0.206. Eighty cars passed through, entered, or left this floor during the survey period, or an average of 11.4 per hour.

Survey 4 of Floor 3E by Recorder Method, March 24, 1932, 10:00 a.m. to 5:10 p.m.

This survey is similar to Survey 3, excepting that the direction of the ventilation on Floor *3E* was reversed; *i.e.*, the air supply openings were closed at the floor and the exhaust openings were closed at the ceiling. In this survey the average of all analyses showed a concentration of 0.288 at the ceiling and 0.229 at the floor. Ninety-five cars passed through, entered, or left this floor during the survey period, or an average of 13.5 per hour.

Survey 5 of Stations 1 and 3, Floors 2E, 3E, and 5E, by Recorder Method, March 25, 1932, 8:33 a.m. to 5:45 p.m.

Both supply and exhaust fans were run at low speed. Riser 6, the air supply riser in the southeast corner of the garage (Fig. 3), was entirely closed on all floors, so that this corner of the building did not receive an air supply from any point closer than Riser 7, 44 ft north along the east wall, and Riser 5, 45½ ft west along the south wall. The purpose of this test was to demonstrate whether or not such an unventilated corner resulted in the building up of a high concentration of carbon monoxide.

Samples were taken at the ceiling and floor at Stations 1 and 3 on Floors *2E, 3E,* and *5E*. The results of the individual analyses are given in Table 3, together

TABLE 3—CARBON MONOXIDE CONCENTRATIONS AT FLOORS AND STATIONS FOR EACH FLOOR—RECORDER

Survey No.	Date	Floor	Stations													
			1			2			3			4			5		
			Time	C.	F.	Time	C.	F.	Time	C.	F.	Time	C.	F.	Time	C.	F.
2	Mar. 22	1W															
2	"	2E							12:59 P. M.	.170	.113				12:32 P. M.	.202	.221
2	"	3W															
2	"	4E							2:54 P. M.	.126	.176				2:28 P. M.	.252	.158
2	"	5E							4:01 P. M.	.139	.107				3:32 P. M.	.315	.221
2	"	5W															
3	Mar. 23	3E	10:56 A. M.	.126	.082	11:19 A. M.	.095	.126	12:05 P. M.	.082	.158	11:41 A. M.	.221	.101			
3	"	3E				4:25 P. M.	.252		5:11 P. M.	.504	.567						
4	Mar. 24	3E	10:25 A. M.	.201	.170	10:47 P. M.	.176	.315	11:34 A. M.	.239	.126	11:14 A. M.	.302	.177			
4	"	3E	4:25 P. M.	.284	.176	4:05 P. M.	.252	.201	4:49 P. M.	.378	.391						
5	Mar. 25	2E	4:05 P. M.	.202	.221				3:45 P. M.	.139	.196						
5	"	2E	4:45 P. M.	.328	.328				4:25 P. M.	.284	.365						
5	"	2E	5:25 P. M.	.933	.756				5:05 P.M.	.567	.788						
				.488	.435					.330	.450						
5	Averages	2E		.462						.390							
5	Mar. 25	3E	8:33 A. M.	.315	.346				8:58 A. M.	.441	.252						
5	"	3E	9:19 A. M.	.410	.315				9:39 A. M.	.189	.170						
5	"	3E	9:59 A. M.	.504	.504				1:45 P. M.	.095	.013						
5	"	3E	1:25 P. M.	.095	.126				2:25 P. M.	.170	.158						
5	"	3E	2:05 P. M.	.095	.032				3:05 P. M.	.050	.126						
5	"	3E	2:45 P. M.	.107	.114												
				.254	.240					.189	.144						
5	Averages	3E		.247						.167							
5	Mar. 25	5E							11:10 A. M.	.378	.328						
5	"	5E	11:30 A. M.	.410	.378				11:50 A. M.	.189	.063						
5	"	5E	12:10 P. M.	.126	.189												
				.268	.284					.284	.196						
5	Averages	5E		.276						.240							
				.320	.301					.250	.246						
5	Averages	2E, 3E, 5E		.311						.248							
9	Mar. 28	1W															
9	"	1W															
9	"	4E	3:31 P. M.	.158	.095				2:50 P. M.	.107	.076				3:10 P. M.	.195	.177
9	Averages	1W, 4E		.127						.092						.186	
9	Mar. 28	3E	10:43 A. M.	.126	.076				10:03 A. M.	.221	.189				10:23 A. M.	.195	.195
9	"	3E	5:15 P. M.	.284	.346				11:04 A. M.	.315	.252				4:51 P. M.	.441	.441
9	"	3E							4:04 P. M.	.378	.239						
9	"	3E							5:38 P. M.	.806	.756						
9	Averages	3E		.208						.394						.318	
22	Mar. 30	3E	1:44 P. M.	.504	.347	2:05 P. M.	1.449	.756							1:24 P. M.	1.512	.819
22	"	3E	2:45 P. M.	.347	.284	3:08 P. M.	1.701	1.071							2:25 P. M.	1.197	.882
22	"	3E	4:05 P. M.	.693	.756	4:15 P. M.	1.197	.536							3:31 P. M.	1.827	.882
22	"	3E													4:35 P. M.	1.323	.914
22	"	3E													4:55 P. M.	1.323	1.323
22	"	3E													5:15 P. M.	1.323	1.134
22	"	3E													5:35 P. M.	1.260	1.008
22	"	3E													5:55 P. M.	1.008	
22	Averages	3E		.515	.462		1.449	.788								1.347	.995
25	Apr. 1	3E	12:35 P. M.	1.575	.945				1:20 P. M.	1.260	.315				1:40 P. M.	1.070	.788
25	"	3E	2:12 P. M.	2.140	.334				2:57 P. M.	.945	.662				3:27 P. M.	1.200	1.200
25	"	3E	3:47 P. M.	1.480	.472				4:47 P. M.	1.389	1.480				5:07 P. M.	1.260	.945
25	"	3E	5:27 P. M.	1.575	.694				6:07 P. M.	2.395	.882				6:27 P. M.	1.070	.567
25	Averages	3E		1.693	.611					1.498	.835					1.115	.875
28	Apr. 2	3E	10:34 A. M.	.693	.473	10:56 A. M.	.378	.211									
28	"	3E	11:16 A. M.	.466	.473	11:36 A. M.	1.830	.504									
28	"	3E	11:56 A. M.	.819	.513	12:16 P. M.	1.890	.882									
28	"	3E	12:36 P. M.	.756	.567	12:56 P. M.	2.394	.756									
28	"	3E	1:16 P. M.	.504	.630												
28	Averages	3E		.647	.531		1.623	.588									

TABLE 3—CARBON MONOXIDE CONCENTRATIONS AT FLOORS AND STATIONS FOR EACH FLOOR—RECORDER

SURVEY NO.	DATE	FLOOR	STATIONS													
			6			7			8			9			10		
			TIME	C.	F.	TIME	C.	F.	TIME	C.	F.	TIME	C.	F.	TIME	C.	F.
2	Mar. 22	1W							12:05 P. M.	.189	.252	11:27 A. M.	.113	.202			
2	"	2E															
2	"	3W				1:35 P. M.	.176	.221	1:59 P. M.	.265	.139						
2	"	4E															
2	"	5E															
2	"	5W				4:36 P. M.	.095	.076	5:01 P. M.	.126	.158						
3	Mar. 23	3E	10:33 A. M.	.441	.202												
3	"	3E															
4	Mar. 24	3E	10:05 A. M.	.473	.273												
4	"	3E															
5	Mar. 25	2E															
5	"	2E															
5	"	2E															
5	Averages	2E															
5	Mar. 25	3E															
5	"	3E															
5	"	3E															
5	"	3E															
5	"	3E															
5	"	3E															
5	Averages	3E															
5	Mar. 25	5E															
5	"	5E															
5	"	5E															
5	Averages	5E															
5	Averages	2E, 3E, 5E															
9	Mar. 28	1W				1:05 P. M.	.132	.453	1:22 P. M.	.284	.189				12:45 P. M.	.258	.252
9	"	1W				2:01 P. M.	.315	.410	2:21 P. M.	.221	.158				1:41 P. M.	.284	.252
9	"	4E															
9	Averages	1W, 4E					.328			.213						.263	
9	Mar. 28	3E															
9	"	3E															
9	"	3E															
9	"	3E															
9	Averages	3E															
22	Mar. 30	3E															
22	"	3E															
22	"	3E															
22	"	3E															
22	"	3E															
22	"	3E															
22	"	3E															
22	"	3E															
22	Averages	3E															
25	Apr. 1	3E															
25	"	3E															
25	"	3E															
25	"	3E															
25	Averages	3E															
28	Apr. 2	3E															
28	"	3E															
28	"	3E															
28	"	3E															
28	"	3E															
28	Averages	3E															

with averages for ceiling and floor for each station and floor number, and averages for ceiling and floor for each station on all three floors, and a final average for both ceiling and floor at each station represented by the two corners of the garage on all floors studied. These averages show concentrations of 0.488, 0.254, and 0.268 at the ceiling, and 0.435, 0.240, and 0.284 at the floor for Station 1 on *2E, 3E,* and *5E* respectively, giving an average of 0.320 for the ceiling and 0.301 for the floor for all samples taken at Station 1, or in the southeast corner, and an average of 0.311 for both ceiling and floor in this corner of the building. In the northeast corner, where the ventilation was not shut off, averages of 0.330, 0.189, and 0.284 were found at the ceiling, and 0.450, 0.144, and 0.196 at the floor line of the three floors respectively, giving averages of 0.250 and 0.246 at the ceiling and floor for all three floors in this corner, and a total average of 0.248 for both ceiling and floor of all levels in this corner of the building. One hundred ninety-five cars passed through, entered, or left the floors on which samples were taken during the period of the survey, or an average of 20.2 cars per hour.

These averages indicate a higher concentration for both stations at the higher floors. It also shows a fairly consistent, though not universal, higher concentration at the ceiling. The averages also show a higher concentration for both ceiling and floor for the southeast corner in which the air supply was shut off.

Survey 9 of Floors 1W, 3E, and 4E, by Recorder Method, March 28, 1932, 10:03 a.m. to 6:00 p.m.

In this survey air supply Risers 1, 2, 8, 9, 10, and 11 (Fig. 3), or all of the air supply risers in the north end of the building, were closed on all floors. Likewise, downcast exhaust Ducts 1, 2, and 3 or all of the exhaust ducts in the south end of the building were closed on all floors, thus allowing air to be supplied only in the south half of all floors, and exhausted in the north half. Samples were analyzed on the recorder throughout the day at Stations 1, 3, 5, 7, 8, and 10 on Floors 1W, 3E, and 4E. One hundred forty-one cars passed through, entered, or left the floors on which samples were being taken during the period of the survey, or an average of 17.6 cars per hour.

The average analyses of all these samples which are shown in Table 3 are as follows: Stations 1 and 8, the south or air supply end, 0.183; Stations 3 and 10, or the extreme north end, 0.250; Stations 5 and 7 in the center of the garage near the main exhaust duct which was in operation at the time of the survey, 0.277; showing the lowest concentration near the air supply, as would be expected. However, the highest concentration was not found in the dead corners, Stations 3 and 10, where it might have been expected, but rather near the exhaust openings.

Survey 22 of Floor 3E by the Recorder Method, March 30, 1932, 1:44 p.m. to 6:05 p.m.

This survey was made on the third floor east, with the supply and exhaust fans running at low speed. Supply Riser 6, Fig. 3, in the southeast corner was blanked

TABLE 4—CARBON MONOXIDE CONCENTRATIONS AT FLOORS AND STATIONS FOR EACH FLOOR—PYROTANNIC

Survey No.	Date	Time	Floor	Stations																							
				1			2			3			5			7			8			9			10		
				F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.	F.	B.L.	C.
7	Mar. 25	9:20- 9:31 P.M.	1E & 1W						5.7							4.7		4.7				3.2		3.2	3.9		3.9
7	"	"	"																			3.2		2.5	4.7		3.2
7	"	"	2E	3.2		2.5	3.9		5.7				2.5		2.5												
7	"	"	"	2.5		2.5	3.2		3.2																		
7	"	"	3E & 3W				2.5		3.0	2.5		3.2	1.9		0.8	3.2		3.2	1.9		3.2	2.5		2.5			
7	"	"	"				1.9		1.9	2.5									3.0		3.2	2.5		2.5			
7	"	"	5E & 5W				2.5		2.5	2.5		2.5	2.5		2.5	3.2		1.9	1.9		1.9	0.8		2.5			
7	"	"	"				2.5		3.2	2.5		1.3							3.2		2.5	3.2		2.5			
10	Mar. 28	9:35- 9:55 P.M.	3E & 3W	2.5	1.9	1.3	1.9	1.6	3.2	3.0	2.5	2.5	3.2	2.5	3.2	2.5	1.9	1.9	1.3	1.9	1.8	1.8	2.0	1.3	1.9	2.1	1.9
11	"	10:08-10:17 P.M.	3E	1.9	3.2	1.9	2.5	1.9	2.5	1.9	3.2	1.8	3.2	2.1	1.9												
11	"	"	"				2.5	3.2	2.5																		
12	"	10:25-10:31 P.M.	3E	2.5	3.2	2.5	2.3	3.2	3.2	3.2	2.5	1.9	2.5	1.9	2.1												
12	"	"	"				3.2	2.5	3.2																		
18	Mar. 29	9:10- 9:20 P.M.	3E & 3W	2.5	3.2	2.5	2.5	2.5	2.5	3.2	3.2	2.5	2.5	3.2	3.2	2.5	3.8	3.8	3.8	3.8	2.5	2.1	2.5	2.1	1.9	3.2	3.2
18	"	"	"				3.6	3.2	3.2													3.0	3.8	3.8			
18	"	"	1E & 1W											2.5			1.3										
18	"	"	2E & 2W											1.9			3.2										
18	"	"	4E											3.0													
18	"	"	5E & 5W											0.3			0.3										
19	"	9:35- 9:44 P.M.	3E	3.2	3.2	3.2	3.4	3.8	3.2	2.5	3.0	3.4	3.2	3.2	3.4												
19	"	"	"				2.5	3.4	3.4																		
19	"	"	1E & 1W											3.2			3.2										
19	"	"	2E											2.9													
19	"	"	4E											3.2													
19	"	"	5E & 5W											0.3			0.3										
20	"	10:11-10:19 P.M.	3E	3.2	3.2	3.2	3.2	3.8	3.8	3.8	3.2	3.8	3.8	3.4	3.4												
20	"	"	"				2.5	3.2	3.8																		
26	April 1	3:00- 3:15 P.M.	3E	0.3	1.7	1.3				1.0	1.3	1.3	0.7	1.3	1.3												
27	April 2	12:20-12:29 A.M.	3E	0.8	0.8	0.8				0.8	0.8	1.3	0.8	0.8	1.3												

off on this floor. All other air supply vents were open.

One car stationed as indicated by *X* in Fig. 3 was idling throughout the survey. Samples were taken at the ceiling and floor of Stations 1, 2, and 5. The average during the survey shows concentrations of 0.462 and 0.515 at the floor and ceiling respectively of Station 1, 0.788 and 1.449 at the floor and ceiling of Station 2, and 0.995 and 1.347 at the floor and ceiling of Station 5. This survey shows marked increase in concentration at the ceiling over that of the floor, but does not show a higher concentration in the unventilated corner.

Survey 25 of Floor 3E by Recorder Method, April 1, 1932, 12:35 p.m. to 6:47 p.m.

During this survey both supply fans were run at low speed. Only one exhaust fan was run at low speed. In other respects the ventilation was normal. Two cars were allowed to idle on Floor 3E throughout the test, one as indicated by *X* and the other as indicated by *Y*, Fig. 3. Samples were taken at Stations 1, 3, and 5, during the period of the survey with the following average concentrations: Station 1, 0.611 and 1.693 at the floor and ceiling respectively; Station 3, 0.835 and 1.498 at the floor and ceiling respectively; Station 5, 0.875 and 1.150 at floor and ceiling respectively. The average for all three stations gave 0.774 at the floor and 1.447 at the ceiling.

Survey 28 of Floor 3E by Recorder Method, April 2, 1932, 10:12 a.m. to 1:36 p.m.

Both supply and exhaust fans were run at low speed. All air supply and exhaust vents on floor 3E were closed, allowing no direct ventilation on this floor. One car was idling as indicated by *X*, Fig. 3. Ceiling and floor samples were analyzed at Stations 1 and 2. Average carbon monoxide concentrations of 1.135 and 0.559 were found at the ceiling and floor, respectively.

It was considered quite surprising that this condition, with no direct ventilation on the floor, resulted in a lower concentration of carbon monoxide at both ceiling and floor than Survey 22, which was made for the same conditions with ventilation. A survey of air movement as indicated by smoke drift showed a marked air change on this level with no ventilation, the air drifting in through the lower half of the elevation of the space from 3W below, and out through the upper half of the floor space into 2W above.

Survey 7 of Floors 1W, 2E, 3E, 3W, 5E, and 5W by the Pyrotannic Acid Method, March 25, 1932, 9:28 to 9:38 p.m.

This survey was made by the pyrotannic acid method of analysis. Both supply and exhaust fans were running at low speed. The ventilating system throughout the garage was otherwise running normally. Two idling cars were placed, one near either corner of each of the floors, east and west, making twenty idling cars in the entire garage; in addition, a car occasionally passed in or out.

The survey was made by taking samples of air in the bottles at Stations 1, 2, 3, 5, 7, 9, and 10 on Floors 1W, 2E, 3E, 3W, 5E and 5W. Six observers did the sampling, resulting in all samples being taken within a 10-min period from 9:28 to 9:38 p.m.

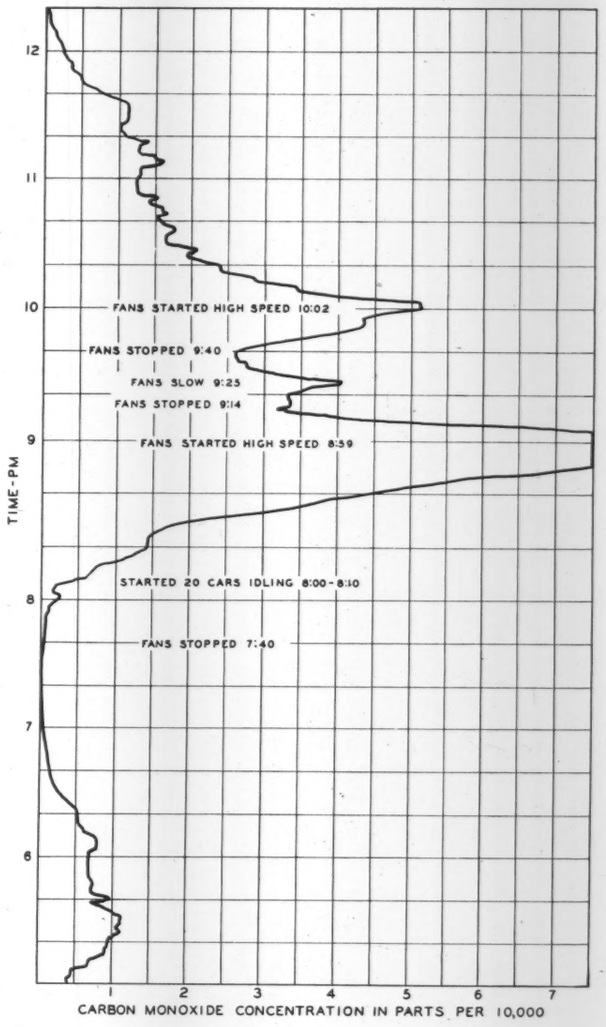


FIG. 7—LOG FROM RECORDER RECORD MARCH 25, 1932. TWENTY CARS IDLING. ABNORMAL VENTILATION AS INDICATED

The concentrations shown by the samples at the different stations are given in Table 4. The analysis shows little consistent variation as between ceiling and floor. However, it does show a progressive rise in concentration from the lowest floor to the highest, with the exception of 3E. At the close of the test, it was found that one of the two cars idling on this floor had stopped.

The condition of the test was obtained by starting all cars idling with the ventilation shut down. Fig. 7 shows how the concentration of carbon monoxide as indicated by the recorder increased between the time the cars were started at 8:00 to 8:10 p.m. and the time when the ventilation was started up at full speed at 8:59 p.m. The fans running at full speed brought the concentration of carbon monoxide down rapidly from the maximum of something over 7.5 parts in 10,000 to 3.2 parts in a period of 15 min. The fans were again stopped at this point and started up at low speed at 9:20. At 9:28 p.m. the concentration was found to be fairly consistent, or in other words, the rate of carbon monoxide generation, together with the air change, approached equilibrium.

Survey 10 of Floor 3E and 3W by Pyrotannic Acid Method, March 28, 1932, 9:35 p.m. to 9:55 p.m. with Moving Cars.

This survey was made with the pyrotannic acid method. The desired condition in the garage was obtained by driving five cars up and down the ramps from Floor 4E, or one floor below where the study was made, up to 2E, or one floor above the floor on which the study was made, and back down. Thus, in making the circuit, each car passed through 3E twice. This arrangement gave about seven cars passing through this floor per minute. The U. S. Bureau of Mines Carbon Monoxide Recorder was kept in operation sampling the air on Floor 3E as a control.

Both supply and exhaust fans were run at low speed. All exhaust ducts in the south end of the building, or Ducts 1, 2, and 3, were closed while all supply risers in the north end of the building or Ducts 1, 2, 8, 9, 10, and 11, were closed, allowing air supply at the south end of the building only, and exhaust at the north end. Stations 1, 2, 3, 5, 7, 8, 9, and 10, on Floors 3E and 3W were sampled between 9:35 and 9:55. The results of the analyses are given in Table 4.

Stations 1 and 8, 3 and 10, and 5 and 7 in the south end, north end, and center of the garage show average concentrations of 1.55 and 1.90, 2.20 and 2.45, and 2.55 and 2.85 at the ceiling and floor of the south end, north end, and the center of the garage, respectively. The average for both ceiling and floor for the south end, north end, and the center of the garage show 1.73, 2.33 and 2.70, respectively.

Survey 11 of Floor 3E by Pyrotannic Acid Method, March 28, 1932, 10:08 to 10:17 p.m.

The condition of ventilation in the garage was the same as in Survey 10, with the exception that on the third floor east the air supply was cut off at the floor and the exhaust was cut off at the ceiling, allowing air to be supplied for this space at the south end half of the garage at the ceiling, and allowing it to be exhausted at the floor through Ducts 4, 5, and 6, at the north end of the garage. Samples were taken of air for pyrotannic acid analysis at five stations on Floor 3E between 10:08 and 10:17 p.m. These results are given in Table 4. No consistent variation in carbon monoxide concentration with station or elevation is noticeable.

Survey 12 of Floor 3E by Pyrotannic Acid Method, March 28, 1932, 10:25 to 10:31 p.m.

The condition of ventilation for this survey was the same as the condition for Surveys 10 and 11, with the exception that in this survey all air supply on the third floor east was shut off at the ceiling line, and all exhaust was shut off at the floor line, allowing air to be supplied to the third floor east at the floor line only from those supply risers located in the south half of the garage, or Risers 3, 4, 5, 6, and 7, and to be exhausted at the ceiling line only through Ducts 4, 5, and 6. Samples for pyrotannic acid analysis were taken at the ceiling, breathing line and floor of Stations 1, 2, 3, and 5, on Floor 3E between 10:25 and 10:31 p.m. The concentrations shown by the analyses of this survey are given in Table 4. No consistent variation in carbon monoxide concentration with station or elevation is noticeable.

Survey 18 of Floors 3E and 3W by Pyrotannic Acid Method, March 29, 1932, 9:10 to 9:20 p.m.

For this survey both supply and exhaust fans were running at low speed. Otherwise, the ventilating system was running normally. Six cars were driven on Floors 2E to 4E, as in Surveys 10, 11, and 12, resulting in seven cars per minute passing through Floor 3E. Samples were taken at the floor, breathing line, and ceiling of stations 1, 2, 3, 5, 7, 8, 9, and 10 on Floors 3E and 3W. The results of the analyses are given in Table 4. No consistent variation in carbon monoxide concentration with station or elevation is noticeable.

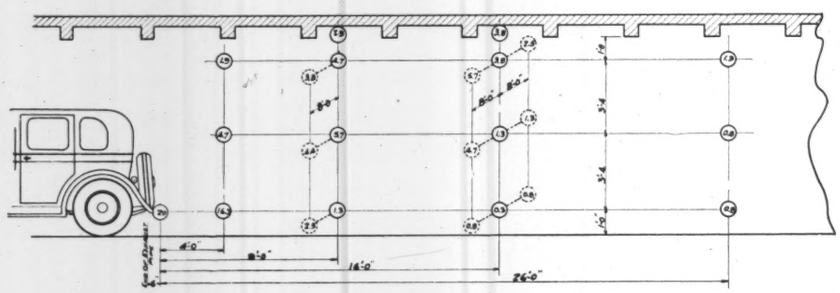


FIG. 8—SURVEY BEHIND IDLING CAR SHOWING CARBON MONOXIDE IN PARTS PER 10,000

One sample at the breathing line at Station 5 on Floors 1E, 2E, 4E, and 5E and at Station 7 on Floors 1W, 2W, and 5W were also taken to indicate the effect of the cars running on Floors 2E to 4E on the floors above and below. These results are also given in Table 4, and show concentrations of carbon monoxide at the breathing line of the top floor practically as high as were found on Floor 3E. There is a slight falling off with descent into the garage until the center of the car activity was reached. Below 4E, the lowest floor on which cars were operating, the concentration of carbon monoxide was negligible.

Survey 19 of Floor 3E by Pyrotannic Acid Method, March 29, 1932, 9:35 to 9:44 p.m.

Both supply and exhaust fans were operated at low speed. All air supply outlets on Floor 3E were closed at the floor, and all exhaust outlets were closed at the ceiling, admitting air only at the ceiling and removing it at the floor. The six cars were operated as in Survey 10. When conditions had reached equilibrium as indicated by the U. S. Bureau of Mines Carbon Monoxide Recorder, samples were taken at the ceiling, breathing line and floor at Stations 1, 2, 3, and 5, on Floor 3E. Samples were also taken at the breathing line of Floors

1E, 1W, 2E, 4E, 5E, and 5W. No consistent variation in carbon monoxide concentration with station or elevation is noticeable on 3E. The same variation in carbon monoxide concentration between the breathing line of 1E and that of 5W is evident as was shown in Survey 18.

Survey 20 of Floor 3E by Pyrotannic Acid Method, March 29, 1932, 10:11 to 10:19 p.m.

Both supply and exhaust fans were operated at low speed. All supply openings on Floor 3E were closed at the ceiling, and all exhaust openings were closed at the floor line, thus admitting air by direct ventilation only at the floor line and exhausting it at the ceiling. The six cars were operated between Floors 2E and 4E, as in Survey 10. The U. S. Bureau of Mines Carbon Monoxide Recorder was operated as a control, and when the carbon monoxide concentration had reached equilibrium samples were taken at the ceiling, breathing line, and floor at four stations on 3E. The results of these analyses are given in Table 4. No consistent variation in carbon monoxide concentration with station or elevation is noticeable.

Survey 21 Behind an Idling Car by Pyrotannic Acid Method, March 29, 1932, 11:30 to 11:45 p.m.

With both supply and exhaust fans operating at low speed, and the ventilating system otherwise operating normally, a survey was made behind a stationary, idling car. Twenty-five samples were taken for analysis, and the results of these analyses are charted with respect to distance and elevation from the rear of the car in Fig. 8. Most of the samples were taken in a vertical plane passing through the exhaust of the car. Three samples were taken at a distance of 16 ft back of the car and 8 ft to the right, and another three samples the same distance back of the car and 8 ft to the left. Samples were also taken 9 ft back of the car and 8 ft to the left. There was a visibly noticeable slight drift of the exhaust gas from right to left which carried it over towards these last mentioned points of sampling.

The analyses show a concentration of 20+ parts of carbon monoxide in 10,000 about 6 in. back of the exhaust opening of the car and directly in the path of the hot gases. The survey further shows that as the exhaust gases pass backwards they rise rapidly, so that they reach the ceiling about 8 to 16 ft back of the car. By placing kerosene in the intake manifold of the car, dense white smoke was made to accompany the exhaust gases from the car, showing clearly the rise in exhaust gases as indicated by this survey. Fig. 9 is a photograph of this rising smoke.

Survey 26 of Floor 3E by the Pyrotannic Acid Method, April 1, 1932, 3:00 to 3:10 p.m.

Conditions of ventilation and car activity for this survey were identical with those of survey 25 made with the recorder, with the exception that samples were taken at the ceiling, breathing line, and floor at Stations 1, 3, and 5, for analysis by the pyrotannic acid method. The results are given in Table 4. This survey shows average concentrations at the ceiling, breathing line, and floor of the three stations of 1.3, 1.43, and 0.67.

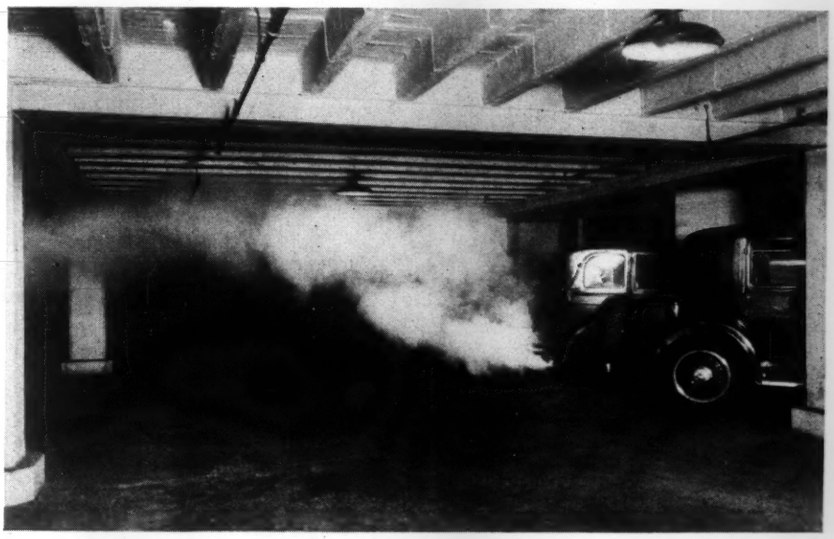


FIG. 9—PHOTOGRAPH OF AUTOMOBILE EXHAUST. (SMOKE PRODUCED BY PUTTING KEROSENE INTO INTAKE MANIFOLD)

Survey 27 of Floor 3E by Pyrotannic Acid Method, April 2, 1932, 12:20 to 12:29 a.m.

This survey was made under the same conditions of ventilation and car activity as Survey 28, excepting that two cars were idling as indicated by *X* and *Y*, Fig. 3, and samples were taken for the pyrotannic acid method of analysis. The results are given in Table 4, and show practically the same tendency as those of Surveys 26 and 28 made by the U. S. Bureau of Mines Carbon Monoxide Recorder, excepting that Survey 27, made with two cars idling, shows a slightly lower average concentration than Survey 26.

Survey of First Floor of the Building with Recorder.

An additional survey was made of the carbon monoxide concentration on the first floor of the building to learn whether leakage from the garage resulted in carbon monoxide vitiated air in the building. A trace of carbon monoxide was found which corresponded in

magnitude with the concentration found in the city street.

Discussion of Results of Surveys

The surveys in the Grant Building Garage show that with normal car operation the ventilation capacity provided by the fans is ample or excessive, and that the amount of air supplied probably can be reduced. Particularly could such reduction in ventilation be made with safety if some instrument for indicating the concentration of carbon monoxide were available to the operating engineer, such as the Carbon Monoxide Recorder developed by the U. S. Bureau of Mines which was used in this survey. A number of these instruments are in use for control of carbon monoxide concentrations in the Holland Tunnel and elsewhere. The cost of the recorder, however, makes doubtful the feasibility of its use, excepting in large establishments.

An indicating instrument based upon the same principles which is less costly has been developed recently. This smaller instrument is limited in sensitivity to ½ part carbon monoxide in 10,000, which should be sufficiently accurate for the purpose.

Practically all the surveys made either with the recorder or by the pyrotannic acid method of analysis show a higher average concentration of carbon monoxide at the ceiling than at the floor. This is particularly true of surveys with normal ventilation and car operation, or with idling cars. It does not noticeably hold true, however, for conditions where a large number of cars are driven through the roadways of the different floors. A ramp garage differs widely from an ordinary one room garage space, regardless of size, in that, in the former many cars drive through any given floor, compared with the number of cars idling or traveling at very low speed, while in the latter the reverse is generally true. Hence, the tendency toward high concentrations of carbon monoxide at the ceiling is interfered with to a greater extent by the mixing effect of moving cars in the ramp garage than in the single room garage.

The conclusions reached in the companion report[3] as a result of visual observations of smoke and surveys in the one floor garage, namely, that exhaust gases from an automobile rise quickly upon leaving a car due to their higher temperature, is borne out by the survey behind a stationary car and the photograph in the Grant Building of the exhaust gases rising behind a car. However, these surveys indicate that comparatively little advantage can be gained by upward ventilation on the different floors of a ramp garage, because of the fact that all of the different floor spaces are interconnected, and also because of the fact that the cars driving through the roadways on the different floors tend to mix the air from the ceiling to the floor.

The surveys with a large number of cars operating on the central floors indicate a marked tendency for carbon monoxide laden air to rise to the floors above, with practically no tendency for the reverse or a downward diffusion to floors below those on which the carbon monoxide is being produced. This may be a characteristic of a ramp garage with interconnecting floor spaces, although it is more likely the result of unbalanced air supply and exhaust from the garage.

A survey with smoke indicated a tendency throughout the garage for upward flowing air currents between all floors. The greater quantity of air supplied to the garage over that exhausted, as indicated by the fan deliveries, will account for this upward flow of air. An attempt was made in the design of this garage ventilating system to deliver like quantities of air to all floors. A survey of Supply Riser 7 and Exhaust Duct 3, indicates the extent to which this was accomplished, for these two ducts. These data appear in Table 5.

TABLE 5—VERTICAL DISTRIBUTION OF SUPPLY AND EXHAUST AIR

Floor	Height Center of Outlet Above Floor	Air Volume from Supply Riser No 7(a) in Cu. Ft. per Min.	Height Center of Inlet Above Floor	Air Volume to Exhaust Duct No. 3(a) in Cu. Ft. per Min.
1	82 10	435 427	60	2414
2	88 10	370 416	78	2363
3	88 10	450 480	78	3358
4	88 10	540 548	78	3642
5	88 10	568 550	78	4319

[a] See Table 2.

If air is supplied uniformly to all of the floors and exhausted uniformly from all of the floors, and if the supply is greater than the exhaust, then the excess of supply must necessarily find an exit, which would naturally be upward to the street, giving a vertical air current through the different floor levels of the garage. That this was the case was evidenced by the fact that a high rate of air leakage took place between the garage space and the other part of the basement to the eastward, separated by the unplastered hollow tile partition. Every crack and crevice through this partition showed a high rate of air leakage.

Because of this upward circulation of air resulting from a higher rate of air supply, it is not possible to conclude that air laden with high concentrations of exhaust gases and carbon monoxide tends to rise to the upper floors because of lower density resulting from higher temperature. However, the fact that the highest concentrations of carbon monoxide in the upper floor spaces where it was not being produced were found near the upper ceiling, rather than uniformly distributed through such floors, would still indicate the possibility of gravity circulation upward of high concentrations of carbon monoxide.

The extent to which change of air from one floor to another takes place is indicated by Surveys 27 and 28, with no ventilation, either supply or exhaust, on the third floor east, but with normal ventilation on other floors of the garage. The concentrations of carbon monoxide found on Floor 3E for this condition were little

[3] Carbon Monoxide Distribution in Relation to the Ventilation of a One-Floor Garage, by F. C. Houghten and Paul McDermott (*Heating, Piping and Air Conditioning*, July 1932).

or no higher than found on this floor with normal ventilation and the same car activity. The reason for this is found in the observed distinct circulation of air into the floor space from below and out at the ceiling.

Surveys 5 and 22, made with no air supply in the southeast corner, indicate the extent to which concentrations of carbon monoxide increased in this corner due to a dead condition or lack of ventilation. While a higher concentration was usually found in this corner when it was not ventilated than was found in the opposite ventilated corner, this difference did not always exist; neither was the difference very great.

The ability of the ventilating system to rapidly bring down the concentration of carbon monoxide, even when it had been increased artificially by running a number of cars and shutting off the ventilating system, is shown in Fig. 7. By taking into account the volume of the garage, the number of cars operating, the amount of air handled, and the rate of increase or decrease in the average carbon monoxide concentration in the garage at any time, it is possible to compute the rate at which carbon monoxide was being delivered to the garage and the rate per car.

The rate of change in volume of carbon monoxide in the garage with time is given by the equation:

$$\frac{dQ}{dt} = V_{co} - Q\frac{V_v}{V_g} \qquad (1)$$

where

Q = volume in cubic feet of carbon monoxide in garage at any time t
V_g = volume in cubic feet of garage
V_v = volume in cubic feet of air supplied per minute
V_{co} = volume in cubic feet of carbon monoxide added to the garage per minute

For the simple case where V_v and V_{co}, or the rate of air change and the rate of carbon monoxide production, are constant the solution of Equation 1 is:

$$Q = \frac{V_g}{V_v} V_{co}\left(1 - e^{-\frac{V_v}{V_g}t}\right) + Q_o e^{-\frac{V_v}{V_g}t} \qquad (2)$$

where

Q_o = the volume of carbon monoxide in the garage at the beginning of the time considered, or when $t = 0$.

Equilibrium between rate of air change and rate of carbon monoxide addition to the garage will theoretically be reached in infinite time, or when $t = \infty$. Substituting this value for t in Equation 2 gives the following expression for the volume of carbon monoxide in the garage when equilibrium has been established with any rate of carbon monoxide production and air change:

$$Q = \frac{V_g}{V_v} V_{co} \qquad (3)$$

If no ventilation or air change is provided the rate of carbon monoxide production is given by the equation:

$$V_{co} = \frac{Q - Q_o}{t} \qquad (4)$$

Two sections of the curve, 9:05 to 9:16 p.m. and 10:04 to 10:24 p.m., Fig. 7, giving the carbon monoxide concentration on the evening of March 25, give conditions from which carbon monoxide production might be calculated by Equation 2. The first of these must be discarded because of unsatisfactory operation of the recorder pen at the time. Using the section of the curve between 10:04 and 10:24 p.m. the values of the various terms in Equation 2 become:

$Q = 140$
$Q_o = 357$
$V_g = 700{,}000$
$V_v = 60{,}000$
$e = 2.71828$
$t = 10:24 - 10:04 = 20$

Solving Equation 2 for V_{co} gives 7.81 cfm of carbon monoxide added to the garage, and 468.6 cfh for 17 cars, or 27.6 cfh per car.

Two sections, 8:10 to 8:50 and 9:40 to 10:00, of the curve, Fig. 7, may be used for calculating the rate of carbon monoxide production from Equation 4, or for a condition of no ventilation while the carbon monoxide concentration is building up from running cars. For these periods the values of the terms in Equation 4 become:

	8:10 to 8:50 p. m.	*9:40 to 10:00 p. m.*
$Q =$	507.5	358.4
$Q_o =$	43.4	183.4
$t =$	40.	20

Solving Equation 4 for V_{co} gives 11.6 cfm of carbon monoxide added to the garage, giving 696.0 cfh for twenty cars or 34.8 cfh per car between 8:10 and 8:50, and 8.75 cfm, giving 525.0 cfh for 17 cars or 30.9 cfh per car between 9:40 and 10:00.

The values of 27.6, 34.8, and 30.9 cfh for the rate of carbon monoxide production per car compare favorably with 29.4 and 31.7 found in the single room garage previously reported. They are lower than the values found by the U. S. Bureau of Mines about ten years ago. This discrepancy can be accounted for by change in motor design or quality of gasoline during the past ten years, or it may be due to air change in the garage other than that measured.

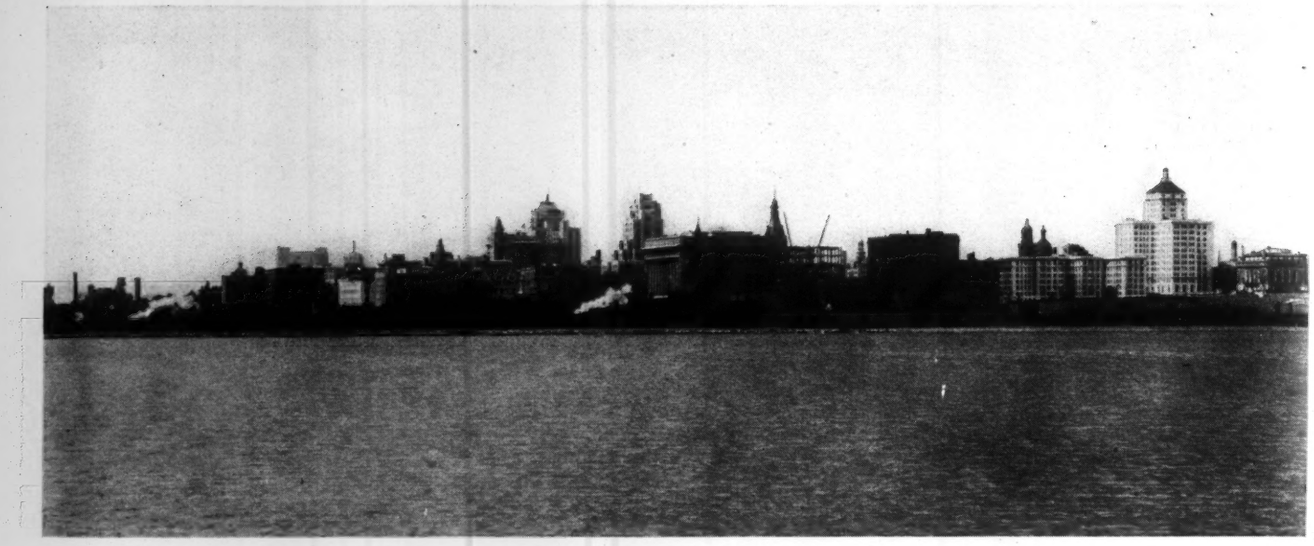
Acknowledgment

The authors acknowledge the kind cooperation of C. E. Traubert of the U. S. Bureau of Mines and H. B. Meller of the Mellon Institute of Industrial Research who aided in making available, calibrating and operating the U. S. Bureau of Mines Carbon Monoxide Recorder, and to W. J. Strassburger and Verne W. Hunter of the Grant Building, who made this building available for the study and assisted in many instances to make the study a success.

Report on Natural Gas vs. Coal

A report of special interest to communities where gas is a factor in heating has just been issued as Bulletin No. 11 by the Engineering Experiment Station, University of Arkansas. The title of the bulletin is *Natural Gas vs. Arkansas Coal for House Heating,* and the report is the work of L. C. Price, Associate Professor of Mechanical Engineering at the University of Arkansas.

From the tests conducted Professor Price concludes that a ton of average Arkansas coal (13,000 Btu per pound), is the equivalent of approximately 21,000 cu ft of 1000 Btu gas for house heating, when the coal is hand-fired.



MILWAUKEE FROM LAKE MICHIGAN

Proceedings of the Semi-Annual Meeting

Milwaukee, Wis. **1932** Hotel Pfister

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

AN EXTREMELY busy three days were enjoyed by the members of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, who gathered in Milwaukee, Wis., June 27-29, for the Semi-Annual Meeting 1932. The registration totalled 335, the largest turnout recorded in several years. In addition to the presentation of 11 technical papers, two items of outstanding interest were the Report of the Committee on Ventilation Standards, which was referred to the entire membership for acceptance by letter ballot, and the Proposed Revisions to the Constitution and By-Laws, which will be sent to the members for comment in advance of the next annual meeting.

The Council accepted the cordial invitation of the newly chartered Cincinnati Chapter to hold the Annual Meeting in January 1933 in Cincinnati.

FIRST SESSION

Monday, June 27, 1932—9:30 A. M.

The first session of the Semi-Annual Meeting 1932 convened at the Hotel Pfister, Milwaukee, Wis., on Monday morning, June 27 with President F. B. Rowley presiding.

E. A. Jones, President of the Wisconsin Chapter, gave a brief address of welcome in which he expressed the pleasure of the local members for the opportunity of entertaining the Society and the desire that everyone would have a pleasant and profitable visit in Milwaukee.

President Rowley responded and remarked that Wisconsin was his home state and also called attention to the coincidence of having an Edwin Jones as President of the Chapter, exactly duplicating the condition two years ago when the summer meeting was held in Minneapolis.

John S. Jung, Chairman of the Committee on Arrangements was introduced and made several announcements relating to the entertainment program which had been arranged for the pleasure of the visiting members and ladies.

The first speaker on a technical subject was J. M. Dallavalle, consulting engineer in the Department of Public Welfare, City of Cleveland, who gave an abstract of his paper entitled, Velocity Characteristics of Hoods Under Suction, (published in *Heating, Piping and Air Conditioning,* May 1932, page 370). President Rowley called for discussion and written comments were contributed by Prof. A. I. Brown, Columbus, O., L. T. M. Ralston, New York, N. Y., and C. A. Booth, Buffalo, N. Y. J. J. Robson, Akron, O., inquired about the method of measuring air velocity at various points and the author described the special tube which he had used. He pointed out that it was made specially for use in a hood or in a room and was not intended for use in duct work.

C. J. Fechheimer, Milwaukee, asked several questions about the tube and other measuring instruments and commented upon the similarity of charts or maps submitted by the author and those which are commonly found in a magnetic field of distribution or an electrostatic field or a heat-flow field.

The paper from the A.S.H.V.E. Research Laboratory, Pittsburgh, entitled, Natural Wind Velocity Gradients Near a Wall by J. L. Blackshaw, and F. C. Houghten, (published in *Heating, Piping and Air Conditioning,* June 1932, page 427), was given by Mr. Blackshaw.

The author stated that it was hoped that the results of the study made at the Cathedral of Learning, University of Pittsburgh, would be useful in correlating film resistance coefficients previously obtained in ducts and that the data could be combined with that previously obtained for practical application. With the aid of slides Mr. Blackshaw gave an interesting description of the apparatus and its operation. The discussion was opened by A. J. Nesbitt, Jenkintown, and Warren Ewald, Philadelphia, Pa.

President Rowley then called upon W. T. Jones for a report of the Committee on Revision of Constitution and By-Laws. Mr. Jones stated that the report of the committee had been printed and it was not the intention to consider the matter in detail, but merely to call the attention of the membership to the fact that the committee had been working for the past two years in an effort to revise our Constitution and By-Laws and the various rules and regulations, so that there would be no conflict and references would be easy to find. The whole subject was divided into three separate sections: (1) Constitution, (2) By-Laws and (3) Rules. Each division has corresponding sections and titles, so that all information on funds which appear in the three divisions can be located under the same number.

It is the suggestion of the committee, Mr. Jones explained, that this report as submitted to the meeting, be sent out to the entire membership with the approval of the Council, so that final amendments can be presented at the Annual Meeting next January. After the Annual Meeting, the Constitution, By-Laws and Rules will then be voted upon by letter ballot. This procedure will make the new Constitution effective in a year, although it is readily understood that the matter could be discussed and final approval delayed for the next 10 years. In addition to the Constitution and By-Laws, the Regulations Governing the Committee on Research will become a part of the Rules.

The following motion was then presented by Mr. Jones: *Resolved,* that the revised draft of the Constitution, By-Laws and Rules and the Regulations of the Committee on Research, after approval by the Council, shall be sent to the entire membership of the Society and then presented at the next Annual Meeting.

The motion was seconded by J. D. Cassell and was unanimously carried.

The session adjourned at 11:30 a. m.

SECOND SESSION

Tuesday, June 28, 1932—9:30 A. M.

The second technical session of the meeting was opened by President F. B. Rowley, who introduced F. C. Houghten, Director of the Society's Research Laboratory, to present the report of the Technical Advisory Committee on Re-Study of the Comfort Chart and Comfort Line, as the Chairman, Prof. C. P. Yaglou, could not attend.

Mr. Houghten reviewed the work, on the relationship of atmospheric conditions to health and comfort, which had been done at the Research Laboratory in cooperation with the Bureau of Mines and the U. S. Public Health Service. Investigation was started in 1920 and the first paper was presented at the Society's Annual Meeting in 1923. Various papers followed on the comfort zone and effective air velocities until more than a dozen had been published on various phases of the subject. The early data applied to persons stripped to the waist and was not intended for conditions of normal activity, and although the difference between the charts for the two conditions was not great, it was significant in ventilation applications. An engineer closely following the various reports would have no difficulty in selecting and using the correct values, but frequently it has been found that an engineer has accepted the data in a particular paper and has even used charts for persons stripped to the waist when designing for school requirements. To eliminate the possibility of such errors, the Committee on Research several months ago, decided to have the whole subject reviewed by a Technical Advisory Committee and in this report a summary of the entire subject is presented. The committee proposes that the term "still air" be discarded and that the expression "lines of equal comfort" might better be referred to as "lines of equal feeling of warmth." As a result of additional studies by Professor Yaglou at Harvard, it is the committee's conclusion that the comfort zone should be limited to relative humidities between 30 and 70 per cent. The point of maximum of comfort selected by the Committee is an effective temperature of 66 deg.

W. W. Schmidt, Madison, Wis., stated that he was specifically interested in the use of the comfort chart for school house conditions and the air conditioning of such structures and inquired how the reactions of an adult might differ from the reactions of a child. He thought that information of this nature would be exceedingly valuable.

W. H. Carrier, Newark, said that the report was of extreme interest to everyone in the heating and ventilating profession and explained that there had been hope of getting another measure of the comfort lines by physiological means. It was surprising to find that practically any point within the zone of comfort gave almost exactly the same total body metabolism.

A. J. Nesbitt, Jenkintown, Pa., referred to the difference in heat production by the student in school and by an adult and Warren Ewald, Philadelphia, inquired about the relationship of racial origin to a person's comfort.

Mr. Houghten advised that the laboratory had collected some comfort data on children which would be published at a later date and it was indicated that school children choose a slightly higher temperature than the adult for comfort. Later reports to be published will give data on metabolism, heat loss and heat dissipation in the atmosphere for children of school age.

Mr. Houghten described some laboratory studies on children which tended to confirm the opinion of Dr. Hill, that people are better off in their activities in an atmosphere on the warm side of the comfort line rather than on the cold side. He stated that no specific study had been made of the comfort zone with relation to the reaction of people of different racial characteristics and from different geographical regions but that it applied particularly to the activities and characteristics of Americans.

A written discussion by Thomas Chester, Detroit, who

considered that the summer optimum effective temperature selected was too low and suggested modifications in tabular form, was read.

Written discussions prepared by Harold L. Alt, New York, and M. C. W. Tomlinson, Urbana, commented on the necessity for uniformity in determining the best indoor conditions for comfort and the terminology used in accurately expressing the various relationships in air conditioning.

President Rowley introduced E. K. Campbell, Chairman of the Technical Advisory Committee on Ventilation of Garages, who also represented the Society on the Garage Committee of the *National Fire Protection Association*. He explained that work has been carried on by the staff of the Society's Research Laboratory in various garages and two papers had been prepared for presentation. Mr. Campbell also announced that the *National Fire Protection Association* had been developing regulations for garages from the standpoint of fire protection and the Society's Code on Garage Ventilation had been approved by the *N. F. P. A.* with some minor changes. Since the completion of the code work, he said, the Technical Advisory Committee had carried on some investigations in St. Louis, in Pittsburgh and later at Lawrence, Kansas in cooperation with the University of Kansas. The present reports cover the work done at Pittsburgh.

F. C. Houghten with the assistance of slides, presented two papers namely—Carbon Monoxide Distribution in Relation to the Ventilation of a One-Floor Garage by F. C. Houghten and Paul McDermott, (published in *Heating, Piping and Air Conditioning,* July 1932, page 495); and Carbon Monoxide Distribution in Relation to the Ventilation of an Underground Ramp Garage by F. C. Houghten and Paul McDermott, (published in *Heating, Piping and Air Conditioning,* August, 1932, page 559.)

A discussion prepared by W. C. Randall, Detroit, was given by J. L. Blackshaw in which the author pointed out that in small garages it is unusual to have two to four cars idling under average working conditions and gave a comparison of results reported in 1929 in the paper Airation Studies in Garages. It was suggested that as the tests were not conclusive for determining the method and amount of ventilation required for best results, that further studies be made.

In the case of the ramp garage, it was suggested that the formula and mathematical computations might be extended to permit calculation of mechanical ventilation required, based on the car-hours-running-time for peak and non-peak loads.

F. C. McIntosh, Pittsburgh, pointed out that these tests form a link in the chain of evidence on correct handling of carbon monoxide and he presented three general questions not discussed in the paper, relating to diffusion of CO and air, other toxic and irritating gases generated and the diffusion of smoke.

J. M. Dallavalle, Cleveland, stated that the investigations showed the value of upward ventilation and served to illustrate how quickly dangerous air conditions can be created under certain conditions of operation and with presumably adequate ventilation facilities.

R. M. Conner, Cleveland, stated that the hazard of carbon monoxide had been recognized by the gas industry and that the *American Gas Association* Laboratory, during its seven years of existence had tested and approved over 20,000 types of appliances. He urged heating engineers to consider the conclusions of the paper very carefully and suggested carrying an adequate safety factor in the design of the system to take care of unexpected conditions.

Mr. Campbell pointed out that in the previous paper of Messrs. Randall and Leonhard, there was no ventilating problem in a garage where windows may remain open with comfort. In the present test bad conditions were created and a study was made of the dangers of such conditions instead of just making ventilation tests in the building. One of the difficulties experienced in considering the garage ventilation problem, he stated, is the lack of suitable instruments which will tell the garage owner when more or less ventilation is needed.

A paper giving the results of cooperative research work of the Society and the University of Wisconsin was announced by President Rowley, who introduced D. W. Nelson, Assistant Professor of Steam and Gas Engineering, who presented the paper entitled, Investigation of Air Outlets in Class Room Ventilation by G. L. Larson, D. W. Nelson and R. W. Kubasta, (published in *Heating, Piping and Air Conditioning,* June 1932, page 438). Several written discussions were contributed and E. H. Beling, Moline, expressed the hope that future investigations would reveal the effect of closing vent outlets in a number of classrooms in buildings of different construction where the same or similar unit ventilators were in operation.

John Howatt, Chicago, mentioned some results of the work in Chicago schools, showing the effect of reducing the area of the air outlets for vents in classrooms supplied from a central system of fans operating at constant speed.

A joint discussion by A. J. Nesbitt, Jenkintown, Pa., and J. D. Cassell, Palmyra, N. J., expressed the belief that the principal value of the paper is to be found in the summary of air supplies under different outlet conditions.

W. C. Randall, Detroit, commented on the phase of the paper dealing with tests of open window ventilation and H. M. Nobis, East Cleveland, raised the objection that the tests were conducted in unoccupied classrooms and suggested that further tests be made with pupils present. C. J. Scanlan, La Crosse, complimented the authors for pointing out the proper way of making heat loss calculations for mechanically ventilated classrooms.

Mr. Houghten mentioned that the State of Pennsylvania had been giving consideration to the elimination of vent stacks in rooms served with unit ventilators but that no definite decision had been reached. Inquiry was made regarding the building up of pressure in rooms without vents causing slamming of corridor doors.

Mr. Ewald called attention to the fact that a unit ventilator is essentially a motor blower and in the comparisons made two types of equipment should be viewed, simply as motor blowers of different fan and motor characteristics.

Professor Nelson in his summary attested to the unpleasant conditions mentioned by Mr. Houghten when a higher pressure existed in classrooms. He explained that the purpose of the paper was to show the results obtained

under various venting conditions and did not propose that the use of vents be discouraged. In reply to Mr. Ewald, the author agreed that the unit ventilator is a motor blower but that the fan used was capable of delivering against a 6-in. pressure and therefore, was quite different from the unit delivering a reasonable air volume running at varying speeds.

President Rowley stated that the next report from the Society's Committee on Ventilation Standards was of exceptional interest to the members. The report presented at the Annual Meeting in Cleveland last January had been thoroughly discussed and the suggestions made had been considered by the committee in preparation of the present report. In the absence of the Chairman, W. H. Driscoll, Prof. A. C. Willard read the statement which had been prepared by Mr. Driscoll.

Discussion of the Report of the Committee on Ventilation Standards

Circumstances which have made it necessary for me to hurriedly change my plans with respect to my attendance at the Society meeting seem to impose on me the necessity of placing before the Society certain views that have been formulated as a result of my experience as Chairman of the Committee on Ventilation Standards.

In this connection, the following is submitted as a discussion of the report to be presented at the Tuesday morning session.

I hope that I may be pardoned if, in my hurry to get this statement off in the earliest possible mail, I may repeat some statements that have heretofore been made on the subject.

The purpose of the committee is not, as some seem to think, to frame a bill for enactment into law in the different states. Its duty is to set up clear and definite standards of ventilation representative of what it believes to be the thought of the Society on this important subject. These standards, when and if adopted by the Society, may be used by individual members, or chapters, or others interested in promoting laws, building codes or health regulations, with the assurance that they have back of them the support and authority of the A.S.H.V.E.

The Society, as a national body, does not propose to concern itself with the promoting or passage of such laws. It is, however, trying to perform a long neglected duty, i. e., the setting up and sealing with its approval of such standards of ventilation as it believes in the light of its experience, its study, and its research activities, properly serve the requirements of human health and comfort.

Your committee has never been optimistic enough to feel that it would emerge from its deliberations with a perfect instrument; nor, on the other hand, does it agree with a few members of the Society who feel that, because this is so, the Society should stand idly by and do nothing.

In considering this subject, the members should bear in mind that the standards of ventilation, like any other standards of the Society, are not necessarily permanent, but are subject to change to meet new conditions and to conform to a more enlightened understanding. This should dispose of the fear expressed by one or two that if we set up a definite air volume of 10 cubic feet we may find in the future that this may be reduced to nine or five, or may be omitted entirely.

Some members have stated that the establishment of ventilation standards lies only within the realm of the physiologist and that the engineer, therefore, should calmly fold his hands and wait for instructions. These members lose sight of two important facts:

First—That the medical profession has wrestled intermittently with the problem for a century and a half, and has yet to produce standards that will serve either the needs or purposes for which our standards are intended.

Second—It is surely the function of the engineer to provide the means for controlling the conditions that are demanded for health and comfort, and it is certainly within his province to work out the engineering problems of air volume, distribution and circulation required to maintain comfort conditions.

The writer has endeavored to keep before the members of the committee at all times the arguments of those who do not favor the inclusion of the definite air volume requirement as set forth in Section V of the report. This seems to be the only real point on which any real issue has been raised. The only difference of opinion in the committee on this issue has been expressed in writing by one member, who incidentally is the only member who has never attended a committee meeting. We have been very particular, however, to place in the hands of very member of the committee a copy of his communication and to give every consideration in and out of the meetings to the views expressed therein.

With this single exception, the committee has been unanimous in its belief that the 10 cubic feet should be retained in the report as written. This belief is based on the statements of those members of the committee, and of the Society, who have had experience in the ventilation of places of assembly and is supported by the investigations made by Mr. Yaglou at Harvard. Furthermore, support for this figure is found in the *Congressional Record,* January 5, 1928, Pages 1067 and 1068. The subject matter of this article is the ventilation and air conditioning of the legislative chambers of the United States Capitol. It contains a report of the committee appointed by the United States Public Health Service to investigate the matter. The chairman of this committee was Professor C.-E. A. Winslow. The report of this committee recommends a minimum of 10 cubic feet of air per person per minute, based on the maximum occupancy of the chambers.

In conclusion, would advise that the writer has been endeavoring to obtain from the medical directors of the large insurance companies of the United States their opinion on this subject. It has been difficult to obtain direct or definite statements because, in general, they do not consider it politic for insurance companies to enter into a discussion of a controversial subject. I take the liberty, however, of quoting the following from one reply that I received:

> "It is well to remember that medicine is an art as well as a science, and while doctors' prefer to base their recommendations on scientifically demonstrated facts, nevertheless, much of our therapy is based simply on what we have learned from experience. No doctor, for instance, knows why the salicylates have proven useful in rheumatism or why mercury should be one of the sovereign remedies for the treatment of other diseases, and yet experience has taught that these remedies are valuable. So no physician knows why fresh air is so important in the treatment and prevention of tuberculosis and in the maintenance of good health in general. We simply know that experience has taught us that this is true."

It seems to me that, in view of the preponderance of opinion in the medical profession of the value of outdoor air and despite the fact that they have never scientifically demonstrated the necessity for a definite quantity per person, that they will not disregard the broad experience of the members of this Society. I am convinced that the medical profession generally will willingly accept the 10 cubic feet as a satisfactory volume until it has been scientifically demonstrated or determined that this volume is not correct. The burden of proof, however, it seems to me, is on the shoulders of those who take exception to this figure, inasmuch as, in the opinion of the committee, it clearly represents the Society's viewpoint.

I am heartily in favor of the adoption of the report as written and sincerely hope that the Society takes such favorable action at the earliest possible moment.

Report of A. S. H. V. E. Committee on Ventilation Standards

COMMITTEE

W. H. Driscoll, *Chairman;* J. J. Aeberly, F. Paul Anderson, L. A. Harding, D. D. Kimball, J. R. McColl, C. L. Riley, W. A. Rowe, Perry West and A. C. Willard.

Preamble

IT IS the intent of the Committee in presenting this report to confine itself to a statement of those requirements which, based on present day knowledge, will provide adequate ventilation for spaces intended for human occupancy. The following standards shall apply to all spaces occupied by human beings in all buildings for which ventilation regulations are to be established.

Section I—Air Temperature and Humidity

The *temperature* and *humidity* of the air in such occupied spaces, and in which the only source of contamination is the occupant, shall be maintained at all times during occupancy at an *Effective Temperature,* as hereinafter stated.

The relative humidity shall be not less than 30 per cent, nor more than 60 per cent in any case. The Effective Temperature shall range between 64 deg and 69 deg when heating or humidification is required, and between 69 deg and 73 deg when cooling or dehumidification is required.

These Effective Temperatures shall be maintained at a level of 36 in. above the floor. (See Appendix, Tables 1 and 2.)

Section II—Air Quality

The air in such occupied spaces shall at all times be free from toxic, unhealthful or disagreeable gases and fumes and shall be relatively free from odors and dust.

In every space coming within the provisions of these requirements and in which the quality of the air is below the standards prescribed by good medical and engineering practices, due to toxic substances, bacteria, dust, excessive temperature, excessive humidity, objectionable odors, or other similar causes, means for ventilating shall be provided so that the quality of the air shall be raised to these standards.

Section III—Air Motion

The air in such occupied spaces shall at all times be in constant motion sufficient to maintain a reasonable uniformity of temperature and humidity, but not such as to cause objectionable drafts in any occupied portion of such spaces.

The air motion in such occupied spaces, and in which the only source of contamination is the occupant, shall have a velocity of not more than 50 feet per minute, measured at a height of 36 in. above the floor.

Section IV—Air Distribution

The air in all rooms and enclosed spaces shall, under the provisions of these requirements, be distributed with reasonable uniformity, and the variation in the carbon dioxide content of the air shall be taken as a measure of such distribution.

The air in a space ventilated in accordance with these requirements, and in which the only source of contamination is the occupant, shall be distributed and circulated so that the variation in the concentration of carbon dioxide, when measured at a height of 36 in. above the floor, shall not exceed one part in 10,000.

Section V—Air Quantity

The quantity of air used to ventilate the given space during occupancy shall always be sufficient to maintain the standards of air temperature, air quality, air motion and air distribution as herein required. Not less than 10 cubic feet per minute per occupant of the total air circulated to meet these requirements shall be taken from an outdoor source.

Appendix—Definitions

For the purposes of these standards the terms used shall be defined as follows:

Ventilation: The process of supplying or removing air by natural or mechanical means, to or from any space. Such air may or may not have been conditioned. (See *Air Conditioning.*)

Air Conditioning: The simultaneous control of all or at least the first three of those factors affecting both the physical and chemical conditions of the atmosphere within any structure. These factors include temperature, humidity, motion, distribution, dust, bacteria, odors, toxic gases, and ionization, most of which affect in greater or lesser degree human health or comfort.

Dry Bulb Temperature: The temperature of the air which is indicated by any type of thermometer which is not affected by the water vapor content or relative humidity of the air.

Dust: Solid material in a finely divided state, the particles of which are large and heavy enough to fall with increasing velocity, due to gravity in still air. For instance, particles of fine sand or grit, such as are blown on a windy day, the average diameter of which is approximately 0.01 centimeter, may be called dust.

Effective Temperature: An arbitrary index of the degree of warmth or cold felt by the human body in response to temperature, humidity, and movement of the air. Effective temperature is a composite index which combines the readings of temperature, humidity, and air motion into a single value. The numerical value of the effective temperature scale has been fixed by the temperature of saturated air which induces an identical sensation of warmth.

Humidity: The water vapor (either saturated or superheated steam) occupying any space, which may or may not contain other vapors and gases at the same time.

Relative Humidity: A ratio, although usually expressed in per cent, used to indicate the degree of saturation existing in any given space resulting from the water vapor present in that space. The presence of air or other gases in the same space at the same time has nothing to do with the relative humidity of the space, which depends merely on the temperature and partial pressure of the vapor.

Spaces in Which the Only Source of Contamination Is the Occupant: Spaces in which the atmospheric contamination results entirely from the respiratory processes of the occupant, including heat, moisture, and odors given off by the body. No manufacturing or industrial processes or other sources of atmospheric contamination, including heat and moisture, than people are considered under this title.

President Rowley announced that the subject was open for discussion and S. R. Lewis, Chicago, said, "It seems to me that this is a report on which action should be taken

TABLE 1—EFFECTIVE TEMPERATURES RANGING FROM 64 DEG TO 69 DEG FOR VARIOUS DRY-BULB TEMPERATURES AND RELATIVE HUMIDITIES FOR STILL AIR FOR PERSONS NORMALLY CLOTHED AND SLIGHTLY ACTIVE[a]

(For use when heating or humidification is required)

DRY-BULB TEMPERATURES (DEG FAHR)	RELATIVE HUMIDITIES (PER CENT)						
	30	35	40	45	50	55	60
	EFFECTIVE TEMPERATURES (DEGREES)						
67						64.0	64.3
68			64.0	64.2	64.5	64.8	65.1
69	64.1	64.4	64.8	65.1	65.4	65.7	66.0
70	64.8	65.1	65.4	65.8	66.2	66.5	66.8
71	65.5	65.8	66.2	66.6	67.0	67.3	67.7
72	66.2	66.5	66.9	67.3	67.7	68.1	68.5
73	67.0	67.3	67.7	68.1	68.5	68.9	
74	67.7	68.0	68.4	68.8			
75	68.4	68.7					
76	69.0						

[a] See A.S.H.V.E. GUIDE 1932, Fig. 2, p. 394.

TABLE 2—EFFECTIVE TEMPERATURES RANGING FROM 69 DEG TO 73 DEG FOR VARIOUS DRY-BULB TEMPERATURES AND RELATIVE HUMIDITIES FOR STILL AIR FOR PERSONS NORMALLY CLOTHED AND SLIGHTLY ACTIVE[a-b]

(For use when cooling or dehumidification is required)

DRY-BULB TEMPERATURES (DEG FAHR)	RELATIVE HUMIDITIES (PER CENT)						
	30	35	40	45	50	55	60
	EFFECTIVE TEMPERATURES (DEGREES)						
73							69.3
74					69.3	69.7	70.1
75			69.1	69.5	70.0	71.5	71.0
76	69.0	69.4	69.9	70.5	70.8	71.3	71.8
77	69.7	70.2	70.7	71.2	71.6	72.1	72.6
78	70.4	70.9	71.4	71.9	72.4	73.0	
79	71.1	71.6	72.2	72.6			
80	71.8	72.4	72.9				
81	72.5						

[a] See A.S.H.V.E. GUIDE 1932, Fig. 2, p. 394.

[b] This table applies primarily to cases in which the human body has reached equilibrium with the surrounding air. A higher plane of summer effective temperatures is required in places of public assembly where the period of occupancy is short, than is required for offices and industrial plants where the period of occupancy is of longer duration. When the period of occupancy is two hours or less, the dry-bulb temperature shall be 72 F plus one-third of the difference between the outside dry-bulb temperature and 70 F, and the relative humidity shall not exceed 60 per cent.

by the membership of the Society after some deliberation, preferably by letter ballot. *I move therefore, that the Report of the Committee on Ventilation Standards be accepted and transmitted to the entire voting membership of the Society, for "yes" or "no" acceptance.* The motion was seconded by H. M. Hart, Chicago and on vote was unanimously carried.

Upon inquiry of J. J. Aeberly, Chicago, President Rowley stated that the process of mailing the Code for vote of the membership would be speeded up in so far as possible, in order that the members could express their opinion promptly.

Prepared discussions were contributed by W. W. Timmis, New York and H. M. Nobis, Cleveland.

THIRD SESSION

Wednesday, June 29, 1932—9:30 A. M.

The final session of the Semi-Annual Meeting, 1932, was opened by President Rowley, who introduced E. K. Campbell, Chairman of the Committee on Chapter Relations. Mr. Campbell gave a brief outline of the committee's efforts to assist the local chapters of the Society with their meeting programs, arrange for speakers and promote closer relationship between the individual chapters. An instance, was the joint meeting of the Kansas City and St. Louis Chapters at Kansas City where Prof. A. C. Willard was the speaker. It was a pronounced success and arrangements are now being made to have a joint meeting in October at the University of Illinois to which the Illinois and Wisconsin Chapter Members will be invited. This committee, he indicated, acts as a general clearing house to aid any chapter and welcomes the ideas of members and officers of these organizations.

With Professor Larson presiding, H. M. Hart, Chicago, was introduced as the special representative of the *Heating and Piping Contractors National Association* and he extended the greeting of the National Association to the members of the Society. He expressed the appreciation of the contractors for the constructive work being done by the Society, a great deal of which is being utilized in the Association's standardization work. He presented a cordial invitation to the Society members to attend the coming annual convention of the Association which is to be held in Chicago in June, 1933.

Chairman Larson then announced the first technical paper on the program, entitled, Thermal Properties of Building Materials by F. B. Rowley and A. B. Algren, (published in *Heating, Piping and Air Conditioning,* May 1932, page 363), and stated that Prof. Algren, Assistant Director of the Experimental Engineering Laboratory at the University of Minnesota, would make the presentation. Prepared discussions were given by Paul D. Close, New York, for Messrs. J. S. Busch, Cloquet, and R. E. Backstrom, Washington, D. C.

The second paper of the morning was entitled Tests of Convectors in a Warm Wall Testing Booth by A. P. Kratz, M. K. Fahnestock and E. L. Broderick, (published in *Heating, Piping and Air Conditioning,* July 1932, page 502), and gave results of cooperative work between the Society and the University of Illinois. M. K. Fahnestock, special research assistant, gave the paper in abstract and with the assistance of slides described the progress of the investigation and the results obtained.

R. M. Conner, director of the *A. G. A.* Laboratory, read a prepared discussion in which he commented upon the results of the tests and also described the procedure used in testing gas steam radiators.

H. F. Hutzel, Waterbury, spoke of the importance of further investigation of the present correction factor used for convector heaters and also related some of his experiences in making accurate measurements of air inlet temperatures.

Warren Ewald, Philadelphia, expressed the opinion that counter-flowing air currents might have some significance and stated that certain tests which he had made showed that loss of air flow through the convection heaters is of greater importance.

F. W. Hvoslef, Kohler, Wis., pointed out that in the tests where he had reduced the stack to a minimum height air flow practically stopped, thereby reducing the heating effect of the convector. He questioned whether the use of a smaller proportion calculated heating surface is justified and if recently published heating effect ratings for convection heaters were acceptable to engineers.

Replies to some of the questions were given by Prof. A. P. Kratz, Urbana, who stated that much more work was thought necessary to get complete correlation between the cold room and the warm room tests. He discussed the results of shielding thermometers and also pointed out that the presence of a cold wall does not follow the action described by a previous speaker because as equilibrium is reached, the portion back of the radiator warms up and serves as additional heating surface and offsets any loss that might occur by cooling in the stack. Answering the inquiry on heating effect in the rating of radiators, Prof. Kratz pointed out that the paper made no attempt to rate radiators in terms of either condensation or heating effect and that data available was not sufficiently definite to answer the question.

Prof. A. C. Willard said that the work at the University of Illinois during a 20-year period covered the performance of various types of heating and ventilating equipment and the data presented in this paper illustrates

a typical case of the great importance of conducting tests on the performance characteristics of all types of apparatus under actual service conditions. Laboratory tests, he explained, are interesting and they are the source of a great deal of discussion as well as a great deal of information but to get the useful facts, operations must be conducted in the same manner as in practice or the information secured may be extremely misleading.

Chairman Larson announced that the work of cooperative studies by the Society and Texas A. & M. College were given in a paper entitled, Loss of Head in Copper Pipe and Fittings by F. E. Giesecke and W. H. Badgett, (published in *Heating, Piping and Air Conditioning,* June 1932, page 443), and in the absence of the author and because of the advance publication of the paper it will be presented by title. Written discussions commenting on the results were contributed by C. A. Hill, Port Huron; Joseph LeGrand, Chicago; and M. B. Watson, Toronto.

The concluding paper was that of C. G. Segeler of the *American Gas Association,* entitled Automatic Gas Burners, (published in *Heating, Piping and Air Conditioning,* July 1932, page 516), which in the absence of the author was presented by E. D. Milener, New York, N. Y., who gave a brief abstract. Written discussions were prepared by W. A. Oates, Lynn; M. T. Clow, Chicago; N. T. Branche, Toledo and W. E. Stark, Cleveland. Comments from the floor were offered by H. B. Johns, Chicago, who emphasized the necessity for watching the oxygen content of flue gases in automatic gas burner installations, and E. A. Jones, Milwaukee, stated that on many hundred installations that have been checked up, he found close agreement between calculated fuel consumption and actual results. He pointed out that one of the author's charts might be misinterpreted unless some revision was made by plotting the dispersion into blocks which would indicate a better average.

R. M. Conner, Cleveland, stated that there are a great many misconceptions about conversion burners because there are so many variables that must be considered with every installation. Test results of this equipment from many sources have often been misleading because test conditions have been practically ideal. The conversion burner has a logical field and a definite place in the heating business, he said, but every job must be carefully engineered to get good results.

In closing, Mr. Milener expressed his appreciation for the suggestions given and explained that the paper did not attempt to designate the relative merits of automatic gas burners or gas designed equipment and stated that the data had been carefully gathered from 32 of the largest gas companies.

President Rowley returned to the chair and said that the matter of membership dues had been in mind of the Council for some time and had been discussed at several Council meetings, with the result that a definite procedure had been outlined in a resolution adopted by the Council June 29, 1932. E. K. Campbell, Kansas City, explained the difficulties the Council had encountered in considering any change in our present dues and suggested that authority be granted the Council to meet any emergency that might develop. The Council's resolution was read by Mr. Campbell which is to be promptly mailed to each member of the Society.

Report of the Nominating Committee

The report of the Nominating Committee was presented by H. M. Hart, Chicago, Ill., and this will appear in the October Journal as required by the Constitution and By-Laws.

The following resolution was offered by Mr. Hart and seconded by J. D. Cassell.

Whereas, Mr. George Mehring of Chicago was a Charter member of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, and

Whereas, he was a member of the group which formed the Illinois Chapter, and

Whereas, its President in 1909, and

Whereas, he did much to aid in the development of the profession and the industry in which he was always a leader, and

Whereas, his spirit has passed on to eternal life;

Be It Resolved, that we, his associates, do bow our heads in respect for the departed friend; and

Be It Further Resolved, that this expression of friendliness and regret be spread upon our records and that a copy be forwarded to the widow and family of the man we knew and revered.

W. W. Timmis, New York, offered the following resolution which was seconded by Mr. Cassell and adopted:

Resolved, that inasmuch as the lower limit of the relative humidity for comfort and health has not been established beyond reasonable question by the research either of this Society or of others; it is the sense of this meeting that the Committee on Research be instructed to conduct research looking toward the determination of such lower limit as soon as practicable, and to report its findings to an Annual or Semi-Annual Meeting of the Society.

Prof. G. L. Larson, Chairman of the Committee on Research, remarked that a study of a lower humidity limit had been planned and would undoubtedly be carried forward as soon as funds were available. He pointed out it was difficult to undertake new work unless special funds were directly provided for this particular investigation.

Prof. A. C. Willard, Urbana, said that Mr. Timmis' resolution was a fine exhibition of the proper spirit and attitude toward the difficult situation in which the Society will constantly find itself involved in the preparation, adoption and perfection of its various codes. The author of the resolution has reasonable doubt about the humidity limit but he does not wish to delay the adoption of a code which is substantially satisfactory and he suggests a reasonable way of obtaining the answer to his question.

Report of Resolutions Committee

Mr. Cassell presented the report of the Resolutions Committee as follows:

Resolved, that a vote of thanks and appreciation of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS be extended to the Mayor of Milwaukee and City Council for the fine hospitality and many courtesies extended.

Resolved, that a vote of thanks and appreciation be extended to the Milwaukee Association of Commerce for the services rendered and the very fine cooperation they have extended during our stay in this city.

Resolved, that a vote of appreciation be extended to the Wisconsin Chapter of the A.S.H.V.E. for their splendid reception of our members and ladies and that we express our sincere thanks for the pleasant and happy events they have provided for our entertainment during the three days of our stay.

Resolved, that a vote of thanks be extended to the management

of the Hotel Pfister for the very fine service rendered our members and guests.

Resolved, that we extend the appreciation of this organization to the Technical and Public Press for the efforts they have extended in giving this Society most desirable and accurate publicity of our sessions.

As there were no items of new business offered for discussion, President Rowley announced that the registration totaled 335, far exceeding expectations and paid a tribute to the Wisconsin Chapter for the work that had been done in entertaining the visiting members and guests.

The meeting adjourned at 12:00 p.m.

Council Meetings

During the Annual Meeting, four meetings of the Council were held at the Hotel Pfister, Milwaukee, with a majority of the members present as follows: F. B. Rowley, Minneapolis, President; W. T. Jones, Boston, 1st Vice-President; C. V. Haynes, Philadelphia, 2nd Vice-President; F. D. Mensing, Philadelphia, Treasurer; D. S. Boyden, Boston; E. K. Campbell, Kansas City; R. H. Carpenter, New York; W. H. Carrier, Newark; J. D. Cassell, Palmyra; E. H. Gurney, Toronto; John Howatt, Chicago; G. L. Larson, Madison; J. F. McIntire, Detroit; and A. V. Hutchinson, Secretary.

At the meeting held on Sunday, June 26, representatives of 8 local chapters were in attendance as well as several guests, as follows: J. J. Aeberly, Chicago; A. B. Algren, Minneapolis; L. C. Davidson, Philadelphia; E. A. Jones, Milwaukee; F. C. McIntosh, Pittsburgh; C. A. Pickett, St. Louis; C. H. Randolph, Milwaukee; W. A. Russell, Kansas City; S. R. Lewis, Chicago; and W. F. Uhl, Minneapolis.

The main topics of discussion were Society finances and consideration of methods for assisting members whose dues are in arrears.

A charter for a Student Section at New York University was granted and the Report of the Committee on Revision of Constitution and By-Laws was presented by W. T. Jones, chairman.

The invitation of the newly chartered Cincinnati Chapter to hold the next Annual Meeting at Cincinnati was favorably acted upon and the dates selected are January 23-25, 1933.

A revised budget was adopted as outlined by the Finance Committee, the amended budget showing an estimated reduction of income of about $6,000 and a reduction of expenses of over $7,500.

Refrigerating Data Book

The first edition of the Refrigerating Data Book has recently been published by the *American Society of Refrigerating Engineers,* 37 West 39 St., New York.

This volume is an assembly of factual information, combined with the criticism and opinion of the various contributors, and is designed to provide a useful reference source. The text section covers 424 pages and includes about 500 figures and tables, whereas the manufacturers catalog data cover 89 pages. A Directory of Distributors is included, as well as a list of *A. S. R. E.* members.

The following subjects are treated in the text section: air cooling, conditioning, air equipment, atmospheric data, brine properties, brine coolers, carbon dioxide ice, climatic data, cold storage plants, cold storage of foods, commercial machinery, compressors, condensers, conductivity, controls, conversion tables, cooling towers, dairy plants, domestic machinery, electrical equipment, fans, freezing of foods, food properties, glossary, heat transmission, ice cream, ice plants, insulation, instruments, motors and electrical equipment, piping, psychrometry, pumps, refrigerants, refrigerators, refrigerator cars, spray ponds, thermodynamics.

Chapter 5, entitled Psychrometry; Air Conditioning, and covering 10 pages, was prepared by W. L. Fleisher and John Everetts, Jr., both well-known members of the American Society of Heating and Ventilating Engineers. Chapter 20 entitled Air Cooling and Conditioning, and covering an additional 14 pages on this subject, was also prepared by Mr. Fleisher.

Reynolds and Halama Organize

The engineering and contracting firm of Reynolds & Halama, Inc. has been formed by T. W. Reynolds and F. D. Halama, to specialize in heating, ventilating, cooling and air conditioning work, with offices at 25 East 26th St., New York City.

Western New York

June 22, 1932. The Annual June Dinner Dance of the Western New York Chapter was held at the Automobile Club in Clarence and was unusually successful. The members with their wives and friends wholeheartedly supported this social gathering, which is the last get-together of the chapter until the meetings in the fall.

D. J. Mahoney, who had left to represent the chapter at the Semi-Annual Meeting of the Society in Milwaukee, sent a telegram expressing his regret at being absent and extending his good wishes for the success of the evening. Brief talks were made by W. E. Voisinet, secretary, Joseph Davis and J. J. Yager.

The committee and officers were very much gratified by the splendid cooperation of members present in this showing of their support to the chapter.

St. Louis

June 4, 1932. The St. Louis Chapter held its annual summer party at the North Hills Country Club, where a dinner and dance, preceded by golf and bridge, was attended by 40 members and guests.

Mrs. Harry Dougherty and Carl Mortiz were the winners of the golf prizes, and table prizes were awarded to those playing bridge.

The party was very successful and everyone present had a most enjoyable time.

Cleveland

June 1, 1932. The June meeting of the Cleveland Chapter was called to order in the rooms of the Cleveland Engineering Society by Pres. W. E. Stark.

W. C. Kammerer reported for his committee investigating the report from the Consulting Engineers Division of the Cleveland Engineering Society. It was moved by C. F. Eveleth that the report be accepted and the committee be discharged. The motion was passed.

The officers elected to serve the chapter for the ensuing year are as follows:

President, R. G. Davis. *Secretary,* F. A. Kitchen.
Vice President, L. H. Pogalies. *Treasurer,* H. M. Nobis.
Board of Governors, W. E. Stark, Vincent Eaton and C. J. Deex.

Following the election, motion pictures were shown which illustrated the use of high speed motion pictures in research. The film taken at the Imperial University, Tokyo, Japan, showed the reaction of the atmosphere to moving objects, and the speed at which some of the pictures were taken, 20,000 per second, made it possible to clearly see what happened to air currents.

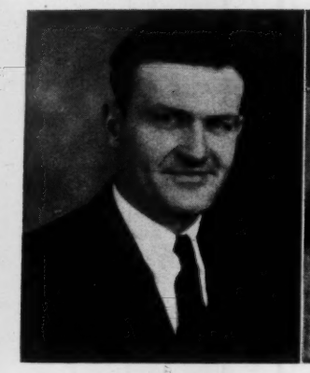
This meeting was the final meeting of the season.

Pacific Northwest

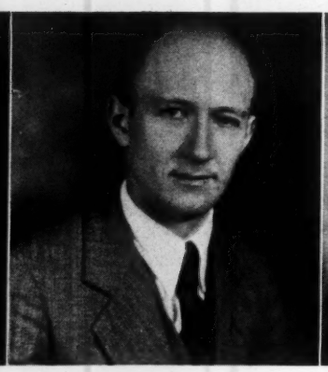
May 26, 1932. At a meeting of the Pacific Northwest Chapter the following officers for the year 1932-33 were installed:

President—C. F. Twist. *Secretary*—S. D. Peterson.
Vice-President—P. M. O'Connell. *Treasurer*—W. W. Cox.

A rising vote of appreciation was given retiring Pres. William E. Beggs for his efforts in the interest of the Pacific Northwest Chapter during the past year.



H. F. HAUPT
Entertainment

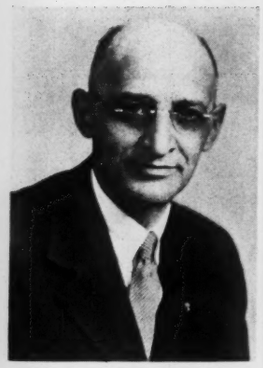


V. A. BERGHOEFER
Finance

C. H. RANDOLPH
Ladies Entertainment

MRS. E. A. JONES
Hostess

JOHN S. JUNG
General Chairman



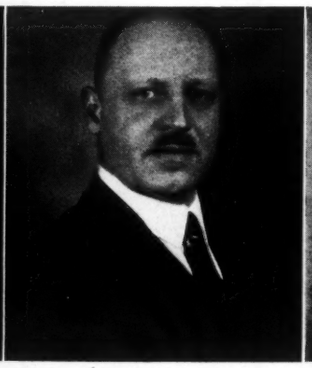
J. G. SHODRON
Reception

W. H. WILSON
Vice-Chairman

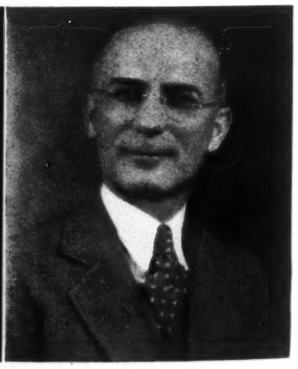
A. M. WAGNER
Transportation

G. L. LARSON
Registration

ERNEST SZEKELY
Publicity



E. A. JONES
Golf



F. G. WEIMER
Banquet

The Milwaukee Plan and What Happened

By Howard F. Haupt

IN THIS brief statement of activities of the Wisconsin Chapter's Committee on Arrangements for the A.S.H.V.E. Semi-Annual Meeting 1932, an outline of the preliminary plans is given with some comments on the program as carried out June 27 to 29th.

At the October 1931 Meeting of the Wisconsin Chapter, official notification was received that the Council had accepted the invitation to hold the Semi-Annual Meeting 1932 in Milwaukee and E. A. Jones appointed John S. Jung, General Chairman, and W. H. Wilson, Vice-Chairman of the Committee on Arrangements. The National Secretary, A. V. Hutchinson was present and on the following day in conference with him the hotel headquarters was selected—the Hotel Pfister. The personnel of the Committee on Arrangements was discussed on November 3 and a dinner meeting was scheduled for November 13 at the Hotel Pfister where the personnel of the complete committee was announced:

John S. Jung, *General Chairman.*
Wm. H. Wilson, *Vice-Chairman.*
H. W. Ellis, *Chairman,* Advisory Committee.
J. G. Shodron, *Chairman,* Reception Committee.
G. L. Larson, *Chairman,* Registration Committee.
A. M. Wagner, *Chairman,* Transportation Committee.
V. A. Berghoefer, *Chairman,* Finance Committee.
H. F. Haupt, *Chairman,* Entertainment Committee.
E. A. Jones, *Chairman,* Golf Committee.
F. G. Weimer, *Chairman,* Banquet Committee.
Ernest Szekely, *Chairman,* Publicity Committee.
C. H. Randolph, *Chairman,* Ladies Entertainment Committee.
Mrs. E. A. Jones, *Hostess.*

In accordance with the suggestion of the Council that morning that sessions only be held on the three days, June 27 to 29, plans were made to provide suitable entertainment for afternoons and evenings. At this first meeting, discussion was of a general nature and we were fortunate in having Prof. G. L. Larson, John Shodron, A. M. Wagner and representatives of the Milwaukee Association of Commerce, who gave valuable ideas regarding appropriate entertainment.

On June 18 a dinner meeting was held at the Hotel Pfister with the members and their wives present. At this time, it was explained what responsibilities the chapter had assumed in planning to entertain the visitors to the Summer Meeting. Now that the meeting is a matter of history, this means of getting better acquainted was considered an important factor in having our members pitch in and work to make the visitors feel at home.

Monthly meetings of the committee were held thereafter and the personnel of each committee was built up by the respective chairman to meet his individual requirements. Correspondence with the headquarters office in New York was conducted through the General Chairman and our good secretary forwarded us such information as would be useful in guiding our efforts. Reports of former meetings were studied and we had the benefit of the information gathered by Mr. Wagner through his activity at the Minneapolis meeting in 1930.

In conference with Secretary Hutchinson a tentative budget was worked up and we estimated an income of $1,612.50 and planned on the expenditure of $1,455, giving us a cushion of $157.50. In this day and age of a balanced budget, we were on pins and needles as to the estimated profit, so we surrounded it with many question marks. However, as each committee had a mark to shoot at, they tried to stay under the estimate without impairing the quality of the entertainment. Later we did become more generous and gave the Banquet Committee a little more to spend. Why shouldn't we, as there was a $157.50 balance to work on?

The date of the meeting was fast approaching and our national secretary advised us to concentrate on perfecting all plans during the last six weeks. One of our committee meetings to test the refreshments was in an out-of-way place where we sat behind locked doors to pass judgment on the quality of a formerly famous liquid. In our committee meetings, now, we discussed matters on the assumption that the meeting had started. What is the first thing to be considered? Naturally, reception. The Chairman, J. G. Shodron, was asked how he had planned the work and when the proper procedure had been explained everyone knows now, that it worked out splendidly. Registration came next with Professor Larson in charge. The work was done by a secretary from the headquarters office and the Association of Commerce had several girls to assist. Lobby signs around the registration desk informed the visitors about the social program and how to get on the bandwagon.

E. A. Jones, the Golf Chairman, told of the plans for the tournament at Ozaukee Country Club and said that plenty of prizes would be available.

The Chairman of the Transportation Committee, A. M. Wagner, reported that he had sent a letter to all manufacturers and sales organizations requesting their cooperation in furnishing private cars and in answer to his questionnaire, information was given regarding the type of car available, and the name of the driver. The chairman communicated with each driver and furnished a windshield sticker as well as a scheduled route for the various occasions for which the car would be required. He had fifty-seven cars available and transportation was not a problem, owing to the fine organization and the long hours of supervision which the chairman and his committee devoted to this work.

The Ladies Committee in charge of C. H. Randolph and Mrs. E. A. Jones, as Hostess, planned their parties so that all of the ladies were away from the hotel when the technical meetings adjourned. A luncheon and bridge party was scheduled at the Milwaukee Yacht Club on Monday. On Tuesday, it was thought advisable to have a sightseeing trip, leaving the hotel at 10:30 a. m. to include a drive along the lake shore, a visit to the zoo and the horticultural display at Mitchell Park. At the conclusion of the trip a luncheon was to be served at a downtown department store, and then the ladies were to roam around and shop to their hearts' content. Monday night was to be an important night and the Entertainment Committee was anxious to provide the proper atmosphere which would be enjoyed by the greatest number and make it a real "get-acquainted" party. The idea was to have plenty of food, good refreshments and snappy music for dancing.

Now how have the Banquet Committee progressed? F. G. Weimer and his assistants were out many nights checking up on orchestras, vaudeville acts and singers. Estimating the number of ladies' favors was a big problem. Some were suitable, but could not be obtained in the desired number, or could not be duplicated if there was a shortage. Others must be bought outright and no returns could be made. The hotel manager, the chairman and Secretary Hutchinson selected the menu and it was excellent. An attractive program was planned and printed and the set-up of the banquet hall was arranged. All entertainment was booked through one agent.

Publicity, an important factor in the success of a meeting, was arranged for by Ernest Szekely, Chairman of the Publicity Committee and Mr. Hutchinson. Local publicity work in newspapers and among the local engineers, architects, and industrial firms was planned while material for the trade press was supplied from the New York headquarters.

A meeting was conducted at the School of Engineering in Milwaukee and addresses on heating, ventilating and air conditioning topics were delivered by Professor Larson, J. G. Shodron and Ernest Szekely. An invitation to attend the Society's Sum-

mer Meeting was extended to all present by President E. A. Jones of the Wisconsin Chapter.

Finances were handled under the direction of V. A. Berghoefer and this committee caused no worry as its biggest job came after the meeting. A man of mature and sound judgment, H. W. Ellis, was appointed to act in an advisory capacity.

On June 13 a "get-together" party of Chapter members and ladies was held and a review of all meeting plans was presented to the audience and everybody left the meeting pepped up to do his part. Th final check-up was held on the Saturday preceding the meeting.

Entertainment

Now the actual meeting is on. What happened to our presumably well laid plans . . . let's see. The greeters were on the job with a hello for everybody, "What can I do for you?"

Registration began at 8:30 a. m. on Monday and the meeting was called to order by President F. B. Rowley promptly at 10:00 a. m.

Ladies Luncheon and Bridge

The Ladies Committee lined up their luncheon and bridge party and left the Hotel Pfister promptly on schedule at 12:00 noon. The Transportation Committee had cars to take the 35 ladies to the Milwaukee Yacht Club where they enjoyed a fine luncheon and had a bridge game in a most attractive setting overlooking Lake Michigan. Those whose efforts were rewarded for their good playing were: Mrs. Chas. Jackson, Milwaukee; Mrs. John S. Jung, Milwaukee; Mrs. S. R. Lewis, Chicago; Mrs. C. W. Miller, Menominee Falls, Wis.; Mrs. Ben Natkin, Kansas City; Mrs. L. J. Pitcher, Chicago; Mrs. C. J. Rice, Milwaukee and Mrs. F. B. Rowley, Minneapolis. Taxis were on hand to bring the ladies back to the hotel where they arrived at 5:30 p. m.

At the conclusion of the technical session at 12:15 p. m. the golfers entered the cars which were waiting at the door and by 12:50 the last car was on its way to the Ozaukee Country Club. Ideal weather prevailed and the course was in splendid condition. As the cars arrived at the club grounds, greens fees were collected and the golfers went to the clubhouse to change clothes and eat luncheon. Fifty men played and those who performed most successfully were: D. S. Boyden, Boston; R. M. Conner, Cleveland; W. R. Fraser, St. Louis; C. F. Hayden, Chicago; R. E. Moore, Chicago; L. J. Pitcher, Chicago; G. W. Reeke, Green Bay; W. H. L. Smythe, Pittsburgh; W. W. Timmis, New York and W. F. Uhl, Minneapolis.

Monday Night Party

At 8:30 in the evening, the crowd assembled for the Old Fashioned German Party, held in the Wisteria Room of the hotel. Tables were all set and a long table piled high with good food occupied one end of the room. The service was buffet style and the menu included hot brat wurst, sauerkraut, assorted meats, sausages, several kinds of cheese, cole slaw, chef's salad, potato salad and apple, blueberry and cherry pies. The refreshment stand at the opposite end of the room provided the individual requirements by the glass, pail or pitcher.

A Croatian orchestra of six pieces played continuously from 8:30 p. m. to 1:00 a. m. and did the audience dance? Just ask any one that was there. Adjoining the dance floor was an attractive roof garden festooned with colored lights, furnished with tables and chairs so that any of the 223 people who attended had a comfortable, quiet place to rest and enjoy their refreshments or discuss important questions. Everybody was happy and the party was a success by unanimous vote of all present.

On Tuesday at 10:30 a. m. sightseeing buses drew up to the hotel and the ladies prepared for a ride around the city along the lake shore, the boulevards, through Washington Park to the Zoo, then over to Mitchell Park noted for its floral display where the park superintendent escorted the group through the gardens and explained the interesting details of the floral groups. The trip ended at one of the large department stores where an excellent luncheon was served after which the ladies were escorted through the store to do any desired shopping.

Immediately after the technical session 20 inveterate golfers started for North Hills Country Club were luncheon was served and a pleasant afternoon was enjoyed. Another group of cars left the hotel at 2:30 p. m. and carried 34 men to the new Engineering and Research Building of the A. O. Smith Corporation, recently completed at a cost of $2,000,000. On Monday afternoon 40 of the members had enjoyed this same trip. Individual inspection trips to plants manufacturing heating and ventilating equipment were made by other groups.

The Banquet

Now for the main event of the meeting—the Semi-Annual Banquet, which got under way promptly at 7:30 with 175 in attendance. During the various courses an excellent stage show was presented under the direction of W. B. Hunter and an excellent orchestra played popular selections. There was something doing all the time, for 12 separate acts were given and at the conclusion of this performance, Toastmaster Larson introduced John S. Jung, General Chairman of the Committee on Arrangements, and E. A. Jones, President of the Wisconsin Chapter, who awarded the golf trophies.

The Research Cup was awarded to R. E. Moore of Chicago who had a low net score of 71. As the Research Cup must be won three times for permanent possession, the Wisconsin Chapter presented Mr. Moore with a miniature silver cup as a permanent reminder of his successful 1932 tournament.

Several vocal selections were given by Leona Helene Jung, soprano, who is the daughter of our General Chairman.

W. T. Jones, First Vice-President of the Society was introduced by the toastmaster and in a brief and appropriate speech in behalf of the Council presented W. H. Carrier, President of the Society in 1931, with a handsomely bound book of clippings recording the important events of his administration. A brief response was made by Mr. Carrier.

A brief address entitled, Planning for Prosperity, by President F. B. Rowley was given.

The toastmaster then introduced John Howatt, Chicago, a member of the Council, who in a very graceful introductory speech presented his old friend, Count Anton Carlson, President of the Scandinavian World's Fair Committee and a prominent engineer who had been visiting in Chicago to make arrangements for the exhibits of Norway, Sweden and Denmark at the Century of Progress World's Fair in 1933. The Count made an address on his impressions and observations in America and his attempts at using American slang were received with enthusiasm by the audience. At the conclusion of his talk he had a surprise in store for members as he introduced that well known radio entertainer Axel Christianson of WGN Chicago, by removing his mustache, glasses and gray wig.

The Banquet Hall was cleared for dancing and to the tune of a ten-piece orchestra everything was O. K. in Milwaukee. Everybody was happy and the Banquet Committee was smiling as the banquet was a success both socially and financially.

With a total registration of 335, an unexpectedly large number, the meeting was voted a great success and many commented upon the very large attendance at all of the technical sessions.

A word should be said for the General Chairman of Arrangements, J. S. Jung, who to all outward appearances had nothing to do except appear on the platform in the meeting, from time to time, to make a few announcements and tell the men where their wives happened to be at the moment and what the committee had planned for them at the conclusion of the session.

When the program had been completed, the Finance Committee got down to business, called in all outstanding money, added up the bank deposits, and collected all bills from the Committee Chairmen, wrote the necessary checks and on Thursday morning found that the slate was clean, and that a better balance remained in the bank than the budget provided. O. K. Milwaukee!

Death of Esten Bolling

Announcement of the sudden death of Esten Bolling at his home in Mountain Lakes, New Jersey, on June 17, came as a distinct shock to his associates and a wide circle of friends.

For the past few years he has acted as a consulting engineer specializing in technical publicity after many years service in engineering work in the field of air conditioning.

Mr. Bolling was born on December 9, 1893, at Wytheville, Va., and after completing his preliminary schooling graduated from the University of Kentucky in 1915 with the degree of B. M. E. and in 1919 received the degree of M. E. from the same institution. His entrance into the heating, ventilating and air conditioning field was with the American Blower Co. in 1915 and 1916. For a short time he was with Greeff Engineering and Manufacturing Co. and then joined the staff of Drying Systems, Inc., as chief engineer in the design and installation of equipment for dehydration of fruits and vegetables. In March, 1918, Mr. Bolling became publicity engineer for the Carrier Engineering Corp. and some of his best known work was done as editor of *The Weather Vein*.

He contributed several papers to the Society and his name frequently appeared in the technical press.

In 1922 Mr. Bolling was active as a member of the Guide Publication Committee and had a prominent part in launching this important Society undertaking. He was keenly interested in its success and later, as chairman of the committee, was associated with its rapid growth.

Mr. Bolling was active in the work of the New York Chapter and served as secretary in 1921-22. He was interested in the development of the local organizations and was a frequent speaker at the meetings of chapters in other cities. He joined the Society as a Junior member in 1918 and was advanced to Member in 1921. He was also a member of the *A. S. M. E.* and several fraternal organizations.

During the past few years, after having been engaged in the manufacturing field, he devoted his time exclusively to technical publicity for several manufacturers of equipment in the heating, ventilating and air conditioning fields. He also had an inventive turn of mind and patented several devices for heating and humidifying.

In Mr. Bolling's death a career of unusual promise and brilliance has been cut short and his many friends in the Society will join in expressing their sincere sorrow to the members of his family who survive.

John A. Flemings

A valuable member of the Society and of the Massachusetts Chapter has been lost by the death of John A. Flemings, who was a native of Massachusetts, having been born at Lowell, Mass., February 24, 1878, and having received his education in the public schools of that city. He attended Massachusetts Institute of Technology and received the degree of S. B. in 1899.

In his engineering work he specialized in combustion and at the time of his death Mr. Flemings was Boston Representative for the Detroit Stoker Co. Previously he had been New England Manager for the Spencer Heater Co., sales engineer for the Combustion Engineering Corp., manager of the Stoker Department of the B. F. Sturtevant Co., and construction engineer for American Engineering Co. Upon his graduation from school his first work was with the telephone companies and, later, he did power station design work and then became chief mechanical draftsman for the Boston Electric Railways.

Mr. Flemings joined the Society in 1929 and took an active interest in its national and local activities. He was a contributor to the technical data section of THE GUIDE, 1932 and his fellow members will regret that death has cut short his active career. The sincere sympathy of the Officers and Council is extended to his family in their bereavement.

Death of Charles R. Honiball

It was with deep regret that advice was received that Charles R. Honiball, consulting engineer of Liverpool, England, and a member of the Society since 1911, passed away suddenly on April 17, 1932, in his sixty-eighth year.

Mr. Honiball was born in Liverpool on May 25, 1864, and received his preparatory education at the Liverpool Public Schools, and his technical education at the Liverpool School of Science and University College.

During his long experience, Mr. Honiball was engaged in many activities relating to the heating and ventilating field, including consulting engineer, designer and manufacturer of heating, ventilating, refrigerating and power installations for land and marine purposes. He also lectured in the Liverpool School of Science and Technical Schools in engineering subjects, mathematics, geometry and graphics, applied mechanics, heat and steam engineering, machine and boiler construction and design.

He was a member of many technical and social organizations.

The Society has lost a versatile and valued member.

George Latham

Word comes that George Latham, engineer and plant superintendent for the Edmonton Public School Board, was accidentally drowned early in June. This tragic happening occurred in his 49th year, as he was born January 23, 1883, in Armagh, Ireland. His engineering experience dated from 1898 when he was a student engineer with the Alec Brown & Co., Londonderry, Ireland. After five years he worked as a construction engineer for the Grand Trunk and Canadian Pacific Railroads and in 1912, he specialized in heating and ventilating work with firms in Edmonton, Alberta, and during the war did ordnance inspection work both in England and in the U. S. for the British Government. Since 1919 he has been in charge of all design and installation of heating and ventilating equipment for the Edmonton Public School Board.

Mr. Latham has been a member of the Society since 1924 and the Officers and Council join in expressing their sincere sorrow to his family and associates for the great loss that they have sustained.

Death of George Mehring

One of the Society's charter members passed away June 4, 1932, at the age of 70, when George Mehring, president of the contracting firm of Mehring and Hanson Co., Chicago, Ill., died at his home in Evanston after a year's illness. Mr. Mehring was very active in the Society's early days and served on the Board of Governors in 1903. He was one of the founders of the Illinois Chapter and gave it sage counsel and guided its early years of activity.

In 1931 Mr. Mehring became a Life Member of the Society and in acknowledgement wrote: "I appreciate highly the honor conferred upon me by the action of the Council and to say that I am pleased expresses it mildly."

Mr. Mehring was a pioneer in the heating industry of Chicago and saw its development during the last half century. In his active and useful life he took a leading part in a great many activities and served loyally and generously, but did not care for office. During all of his life he found pleasure in inspiring and helping younger men and many of his friends feel a deep personal indebtedness to Mr. Mehring for his wise and instructive assistance.

A good and loyal friend has been lost in the death of George Mehring and the Officers and Council express their sincere sorrow to his widow and daughters, who survive. Funeral services were held June 6 at Rosehill Chapel.

Louis J. Sommer

On June 4, the death occurred of Louis J. Sommer, Jr., proprietor of the heating and plumbing contracting firm of Louis J. Sommer & Son, Philadelphia.

He was a native of Philadelphia, having been born there December 2, 1878, and received his education in the schools of the city. In 1904 he entered the business carried on by his father and since 1920 has been the owner and operator of the firm. During his long and active career in the contracting business, he was responsible for the installation of many large heating plants in and around Philadelphia. They are to be found in public institutions, industrial plants, apartments, and public buildings.

In 1922 he became a Member of the Society and has been active in Philadelphia Chapter work.

The deep sympathy of his fellow members is expressed to his widow who survives.

George K. Burgess

Dr. George K. Burgess, director of the Bureau of Standards, and a well known physicist, died July 2 at the age of 58 years. Dr. Burgess had been director of the Bureau since 1923 after serving in the same organization for 20 years. He was best known among scientists for his work in heat measurements and metallurgy and was honored by election and appointment to numerous offices in the world of science.

He was chairman of the National Research Council from 1928 until 1931 and at various times had been president of the *American Society for Steel Treating*, the *American Society for Testing Materials*, the *Washington Academy of Sciences* and the *Philosophical Society of Washington*.

After studying at the Massachusetts Institute of Technology and at the University of Paris, where he received the degree of Doctor of Science, he taught physics at M. I. T. and at the Universities of Michigan and California before going to the Bureau of Standards in 1903, two years after its inception.

He worked so successfully there that in 1914 upon the organization of the work in metallurgy he was chosen chief of the division. He succeeded Dr. W. S. Stratton as head of the bureau when the latter left to become president of M. I. T.

Dr. Burgess' administrative and scientific activities still left him time to translate from the French and he also was author of books on the gravitational constant, experimental physics, and the measurements of high temperatures.

During the administrations of Dr. Stratton and Dr. Burgess, the bureau grew from a small organization of fourteen members, housed in temporary quarters, to a university-like collection of twenty-odd buildings on a site of forty-three acres, where more than 1,100 scientists and associates work.

He was born in Newton, Mass.; descended from Thomas Burgess, who came from England in 1638. His wife, the former Mme. Suzanne Babut, of Aix Limoges, France, survives.

William Woodbury Underhill

In Brookline, Mass., on Saturday, June 4, William Woodbury Underhill, son of Lora A. and the late Charles William Underhill of Boston, died. He was born January 18, 1865, in Winchester.

After graduation from the Winchester High School in 1884 he entered Massachusetts Institute of Technology where he was graduated in 1889 as a mechanical engineer. During his summer vacations he was occupied in drafting in the office of his uncle, E. Frank Woodbury, at Boston, a mechanical engineer and solicitor of patents, who received his education at the same institute. The latter was associated with his father, the late James A. Woodbury of Winchester, also a mechanical engineer.

Immediately after graduating, Mr. Underhill entered the employ of the Smead Heating and Ventilating Co., Boston, and remained with them until their removal to Colorado in 1894.

That year he became associated with the Fuller & Warren Heating & Ventilating Co., Troy, N. Y., his former chief competitor, first as salesman, then as manager of the Boston office, which included the territory of the New England States.

In April, 1910, the Stone-Underhill Heating & Ventilating Co. of Boston was formed, which was sole New England agent for the Fuller & Warren Co.'s schoolhouse apparatus. Eugene R. Stone, at that time Mayor of the city of Quincy, was made president and Mr. Underhill, treasurer.

In 1913 Mr. Underhill joined the Society and took an active interest in this work both nationally and locally. Mr. Underhill was affiliated with many fraternal organizations. He was initiated into the Brookline Lodge of Elks, No. 889, Oct. 3, 1904; served as treasurer three years, chairman of the board of trustees six years, and later was made a life member.

He became a Master Mason in Bethhoren Lodge of Masons, Brookline, June 13, 1921, and was also a member of York Rite, St. Paul's Royal Arch Chapter, Boston Council Royal and Select Masters, Boston Commandery of Knights Templars, Scottish Rite, Lodge of Perfection, Rose Croix, Massachusetts Consistory S. R. R. S. 32nd Degree of Boston, and of Aleppo Temple of the Mystic Shrine.

On October 14, 1893, Mr. Underhill was married in Winchester by Rev. A. W. Littlefield to Elizabeth A. Feltmate of Boston. For 34 years he had resided in Brookline where he was an active member of the Harvard Congregational Church and president of the Harvard Church Brotherhood.

His widow survives him with a son, Earl Woodbury Underhill, and a granddaughter; also his mother, Mrs. Lora A. Underhill of Brookline, and three sisters.

Van H. Manning

In the death of Dr. Van H. Manning at his home in Forest Hills, N. Y., July 13, at the age of 70, the field of research suffers a great loss and those pioneers in the Society who established the Research Laboratory and received the encouragement and assistance of Dr. Manning will be saddened by the news.

Dr. Manning was director of the U. S. Bureau of Mines from 1915-1920, resigning to take the post of director of research for the *American Petroleum Institute*. He was best known for his wartime work in the production of helium and directed the experimenting of 1900 engineers and chemists in the research which brought the cost of helium from $1700 a cubic foot to just a few cents per cubic foot.

Dr. Manning was born at Horn Lake, Miss., and attended the University of Mississippi from 1878-1881 and began his professional career as a civil engineer with the U. S. Geological Survey in 1886. In 1910 he became identified with the U. S. Bureau of Mines as assistant director.

When the establishment of a Research Laboratory by the Society was proposed, Dr. Manning offered the facilities of the Bureau and encouraged the establishment of a cooperative program, which could be mutually helpful.

Dr. Manning was honored as a scientist by many institutions, receiving the honorary degree of Doctor of Engineering from the University of Pittsburgh in 1919. He was a Fellow of the *American Association for the Advancement of Science*, member of the *American Association of Petroleum Geologists, American Chemical Society, American Institute of Mining and Metallurgical Engineers, American Mining Congress, American Society for Testing Materials, Coal Mining Institute of America, Mining and Metallurgical Society of America*, and an honorary member of the *Petroleum Technologists*, of London. Dr. Manning's clubs were the Cosmos, in Washington, and the Engineers' and the Bankers' in New York. He is survived by his wife, Mrs. Emily Stevens Manning, and two sons to whom the Officers and Council send their sincere sympathy.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 4 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by August 15, 1932, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
AXEMAN, JAMES E., Br. Mgr., Spencer Heater Co., Baltimore, Md. (*Advancement*)	A. A. Ahlff M. C. Gillett	N. E. Sheldon
HARRINGTON, ELLIOTT D., Mgr., Com. Engrg. Div., Air Cond. Dept., General Electric Co., Schenectady, N. Y. (*Advancement*)	D. S. Boyden W. H. Carrier	A. V. Hutchinson P. D. Close
MCLOUTH, BRUCE F., Engr., Schmidlin Bros. Co., Toledo, O.	J. H. Van Alsburg H. T. Richardson	F. R. Bishop H. E. Sperling
TUVE, GEORGE L., Assoc. Prof. of Mech. Engrg., Case School of Applied Science, Cleveland, O.	F. B. Rowley M. B. Wright	F. W. Hvoslef R. E. Backstrom

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BRAUN, JOHN J., Factory Mgr., U. S. Playing Card Co., Cincinnati, O.

FAHNESTOCK, M. K., Special Research Asst. Prof., Univ. of Illinois, Urbana, Ill. (*Reinstatement and Advancement*)

FREITAG, FRED G., Consultant, Sylvestre Oil Co., Mt. Vernon, N. Y.

HAJEK, WILLIAM J., Br. Mgr., Minneapolis-Honeywell Regulator Co., Boston, Mass.

HOPPER, GARNET H., Engr., Taylor-Forbes Co., Ltd., Toronto, Can. (*Reinstatement*)

JONES, DAVID J., Control Engr. & Mgr., Accessory Div., Holland Furnace Co., Holland, Mich.

MOTZ, O. WAYNE, Mech. Engr., Samuel Hannaford & Sons, Cincinnati, O.

TENKONOHY, R. J., Vice-Pres., Airtherm Mfg. Co., St. Louis, Mo. (*Reinstatement*)

WHITE, JOHN C., State Power Plant Engr., State Bureau of Engrg., Madison, Wis.

JUNIORS

BADGETT, W. HOWARD, Research Asst., Texas Engrg. Experiment Station, Agric. & Mech. College of Texas, College Station, Texas

THOMPSON, DONALD, Safe Harbor Water Power Corp., Baltimore, Md.

TREADWAY, JOHN QUENTIN, Sales Engr., Clarage Fan Co., Toledo, O.

STUDENTS

ABRAHAM, LEONARD, New York University, New York, N. Y.
AUSTIN, HERBERT F., JR., New York University, New York, N.Y.
BARBERA, HENRY A., New York University, New York, N. Y.
BRUCKMANN, JOHN C., New York University, New York, N. Y.
JANCO, NATHAN, New York University, New York, N. Y.
MAIMAN, HERBERT, New York University, New York, N. Y.
O'HARE, GEORGE W., JR., New York University, New York, N. Y.
RAFFES, ABRAHAM, New York University, New York, N. Y.
REDFIELD, CLARKE, New York University, New York, N. Y.
ROZETT, WILLIAM, JR., New York University, New York, N. Y.

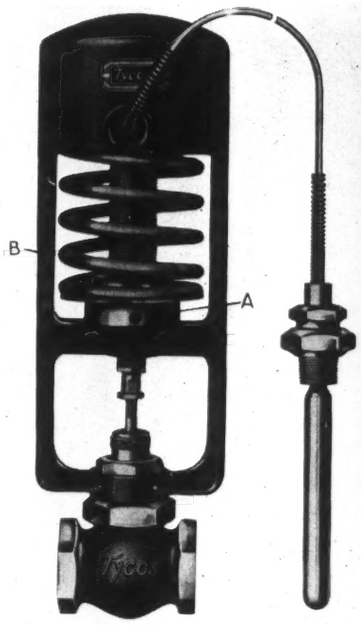
Heating · Piping and Air Conditioning
EDITORIAL

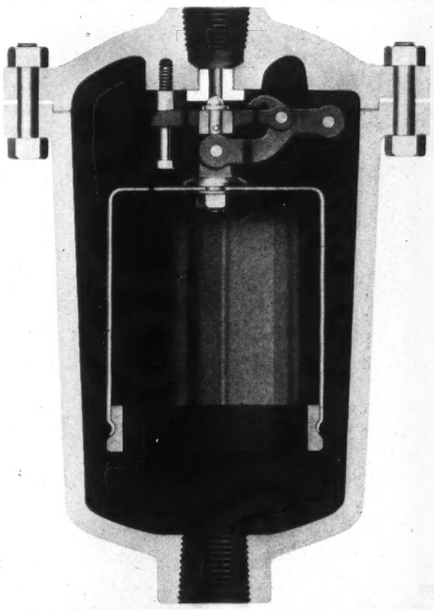
HIDDEN TREASURE

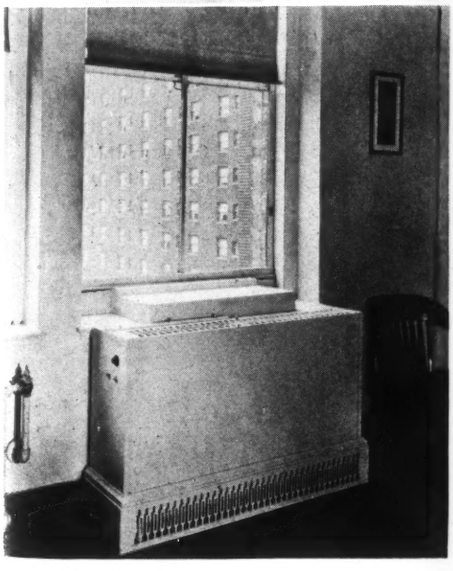
"Hidden treasure lies in maintaining a proper balance between direct and indirect costs," according to R. S. Payne, industrial engineer, in an article describing how his company reduced operating costs of its maintenance division 40 per cent. His article appears in a recent issue of the Executives Service Bulletin, *published by the Policyholders Service Bureau of the Metropolitan Life Insurance Co. As an example, an annual saving of approximately $30,000 was accomplished by revising the routine plant maintenance and providing the proper equipment.*

That hidden treasure can be found in many plants seems apparent; numerous actual examples support this point of view. To mention but a few, in the June HEATING, PIPING AND AIR CONDITIONING a daily saving of $11.64 due to a piping arrangement was reported; in May, the method one plant uses for obtaining its process steam and power was described and it was estimated that a $70,000 saving would be made in the next ten years. How a hotel made a 14½ per cent fuel saving was reported in the April issue; in March, an air-conditioning system arranged to enable operating economies was described.

A careful survey of the heating, piping and air conditioning equipment in industrial plants, office buildings, hotels, hospitals, schools and other structures will invariably show opportunities for cashing in on hidden treasure, through the use of a better piece of equipment, a logical change in the layout of a system, or an improved maintenance program. A treasure which remains hidden is a loss.







INTERESTING Equipment..... Developments

Friction in Regulator Minimized

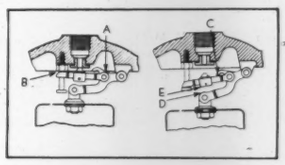
THE improved self-acting type of temperature regulator at the top of the illustration on this page has been designed so that friction is minimized. The theoretically perfect action of such a regulator is that the position of the valve should always be the same for a given bulb temperature and should move in direct relation to changes of bulb temperature. Where friction in the instrument is high, the bulb temperature must change several degrees before the position of the valve disc is changed; in the instrument shown this "dead" period has been reduced to a little over 1 F.

Another feature of this regulator which adds to its performance and adaptability is the construction of the tube system. This consists of a double seamless bellows heavy-walled copper connection tubing and a stainless-steel bulb of small size and thin wall, designed so that the instrument will respond quickly to temperature changes. An overheating feature permits heating the bulb beyond the upper range of the instrument without damaging it.

This regulator is made by the Taylor Instrument Companies of Rochester, N. Y.

Bucket Trap Action Improved

IN the new inverted bucket trap illustrated in the middle view the body is substantially full of water during operation at all times. Air escapes through a small vent in the top of the bucket and collects in the top of the trap ready to go out in the next discharge. Steam also escapes through this vent condensing in the water above the bucket. As the air and steam is replaced in the bucket by water the bucket loses its buoyancy.



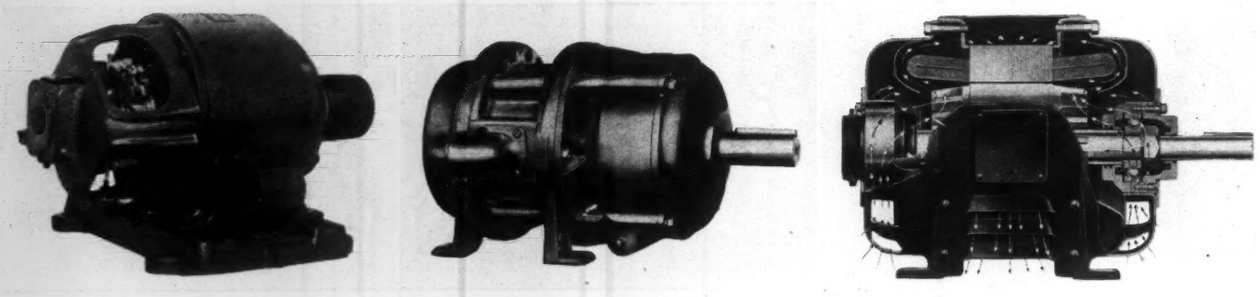
When the bucket sinks, it pulls the disc lever down at *A*. The other end of the disc lever pries against the guide post at *B*, which multiplies the leverage for cracking the valve disc from its seat.

When the disc is cracked from its seat, the "kicker" on the bucket lever strikes the valve lever at *C*, forcing the disc and disc lever clear of the discharge opening. When the bucket rises, the bucket lever *D* strikes the disc lever at *E* and snaps the valve to its seat.

The manufacturer is The Swartwout Company, 18511 Euclid Ave., Cleveland, Ohio.

Keeps Out Noise, Conditions Air

THE unit air conditioner illustrated at the bottom of the accompanying illustration is available in three models, two of them for installation in existing buildings for the elimination of noise, ventilation, and air cleaning and the third for installation in new buildings; three



models which provide these three factors plus humidification and heating and three models which accomplish the foregoing plus dehumidification and cooling.

Each unit is self-contained and designed to care for the room in which it is located. Fresh air at the rate of about 300 c. f. m. is drawn from outside through an air filter and then through a sound-absorbent labyrinth. A rheostat permits control of the motor which governs the amount of air circulated. Recirculated air is drawn through a sodium hydrate filter to remove bacteria and odors.

Humidification is provided by an automatically-operated water reservoir containing a specially-designed radiator. A cooling coil placed in the enclosure provides dehumidification and cooling in summer.

These units are made by the Campbell Metal Window Corporation, 100 E. 42nd St., New York City.

Three Motors Developed

ONE of a new line of direct-current motors which embody refinements of design and construction and have been developed by the General Electric Company (Schenectady, N. Y.), is illustrated above at the left. Mechanically, these motors are so designed that many variations, such as different degrees of enclosure for various applications, can be accomplished by using only a few different parts. New pulley-end shields afford maximum protection to the motor windings; drop-forged feet welded to the motor frame reduce the possibility of breakage. The insulation used is resistant to moisture and weak acids. Properly-proportioned stabilizing windings make possible stable operation. The speeds of all constant-speed motors can be increased 25 per cent, and more in some ratings, by field control.

The center view shows a gear motor recently announced by this company. The underlying principle of these gear-motors consists of a normal speed motor in combination with a built-in, internal-helical planetary-gear speed-reducer. It is stated to be possible to adapt a gear-motor to almost every type of low-speed drive.

Gear-motors with special electrical characteristics, such as high starting torque with low starting current, normal starting torque with low starting current, adjustable, varying speed, multispeed, etc., or mechanical features such as totally enclosed; totally enclosed, fan-cooled; or Class I, Group D, construction for use in hazardous gas locations, are available.

A-c., polyphase, squirrel-cage and wound-rotor gear-motors are available in ratings up to 75 hp., single phase to 5 hp., and d-c. to 7½ hp. D-c. gear-motors are offered for those applications where either the advantages of adjustable-speed drive or a d-c. source of supply render their use desirable. Standard gear motors can be had with shaft speeds down to 13 r.p.m.

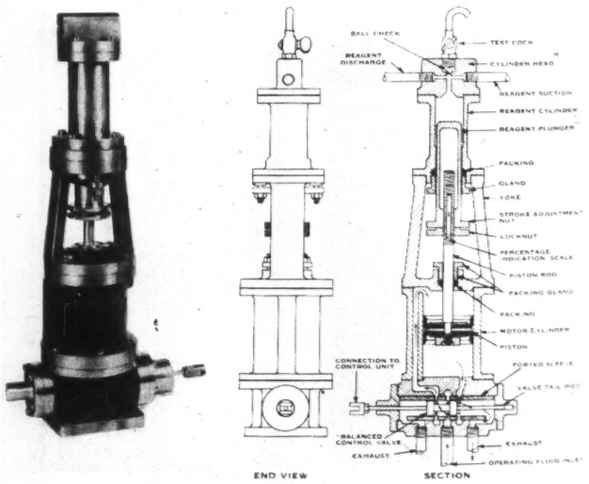
The right-hand view shows a splash-proof induction motor designed particularly for application in which open-motor operation is handicapped by the presence of splashing or dripping liquids.

The end shields are of special construction, the top half being solid to exclude dripping water and liquids. Cooling air enters through ventilating openings in the bottom half of the end shields, a special baffle, which extends to the center line of the motor shaft, preventing the entrance of splashing water into the windings.

The motor frame is protected against the entrance of dripping water and liquids by a one-piece cover, which is fitted to the motor frame. The ventilating air, which enters through the end shield openings, is circulated over the end windings, across the motor frame, and out through louvres in the protective cover. A water-tight conduit box protects the motor leads against damage by dripping or splashing water.

Controls Injection of Chemicals

FOR controlling injection of accurate percentages of chemicals or reagents in treating operations or for securing samples of liquids, the proportioning pump shown is of aid. Operation is controlled by rate of flow of untreated fluid, the mechanism responding to the through-put of the line to which it is attached. Pump injections in direct ratio to the quantity of fluid being treated are frequent.



The assembly consists of a hydraulically-balanced control valve, shuttled back and forth so as to control the number of strokes per minute taken by the small fluid motor located immediately above the shuttle valve. The fluid motor is direct connected to a single-stroking plunger pump, which creates necessary suction and discharge to pick up reagent from any receptacle, build it up to pressure, and discharge it into the untreated fluid.

The access yoke contains the reagent plunger adjusting and locking device, so that dosage may be adjusted by changing length of plunger stroke. Ratios from a few parts per million up to normal reagent percentages may be handled. The reagent is in contact only with the cylinder and plunger, which can be furnished in a wide range of sizes and materials to resist the actions of reagents handled; for corrosive or abrasive fluids a diaphragm is substituted for the plunger.

The manufacturer, %Proportioneers%, 7701 Avalon Ave., Chicago, Ill., suggests the following uses:

Water conditioning.
feeding prepared compounds.
feeding Lime Soda Ash solution.
feeding Sodium Aluminate, etc.
Acid treatment of gasoline pressure distillate, etc.
Chlorinating.
Proportioning stench liquids to natural gas.
Sampling of fluids automatically.
Driving dry feed chemical devices in ratio to flow rate.

A Blowpipe; an Extensometer

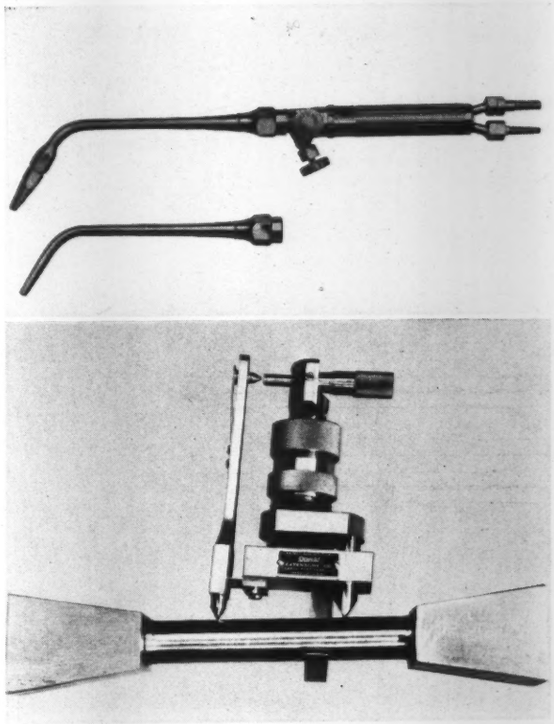
A NEW welding blowpipe has been developed primarily for use on pipe-line work, but its application is not restricted to that field.

Oxygen and acetylene valves are located on the front of the handle, so that flame adjustments may be made readily while the blowpipe is in operation. The acetylene valve is located on the left side of the front of the handle where the operator's right thumb can conveniently regulate it. The oxygen valve is on the under side of the handle; this arrangement makes it unnecessary for the operator to use his left hand, which is holding the welding rod, to adjust the blowpipe valves.

A special feature of the blowpipe is the long acetylene passageway between the acetylene valve and the injector to minimize the possibility of flashback. This is accomplished by having three acetylene tubes between the rear and front bodies. Thus, the acetylene comes from the hose connection up to the valve in the front body, passes through a second tube back to the rear body, thence through a cross drilling to a third tube leading to the injector.

The ball-type acetylene valve on this blowpipe consists essentially of a stainless-steel sphere which is hardened and ground by a new process. This sphere gives a narrow line of contact and is said to eliminate difficulties which might be caused by the deposition of carbon in the valves. The Linde Air Products Company, 30 E. 42nd St., New York City, is the maker; this concern also has recently announced the extensometer shown by the lower half of the cut.

This is a testing device which makes it possible to determine the yield point of specimens being tested in a portable tensile testing machine.



The two points of the extensometer are clamped on the specimen to be tested so that the elongation between the two points during tension is multiplied in a ratio of 5-to-1 by a lever bar making electrical contact with the micrometer head. The moment of contact is indicated by the flash of a small electric light in the extensometer head. The illustration shows the extensometer attached to a specimen ready to be tested in a tensile testing machine.

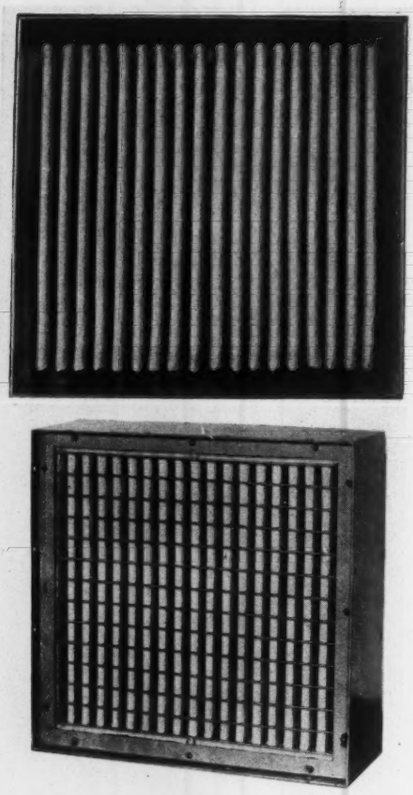
To determine the yield point the micrometer head is backed off two complete turns (0.050 in., which allows for the 5-to-1 ratio in the lever bar) from the zero reading (the point at which electrical contact is broken) for the specimen and the load is applied, increasing the tension until the light flashes. The flash indicates that the yield point has been reached, and this may be read from the load-indicating device on the tensile testing machine.

Filter Employs Felt Glove

A NEW type of air filter made by the Coppus Engineering Corporation, Worcester, Mass., employs an all-wool felt glove stretched over a specially designed wire spacer frame as the filtering medium.

The glove is not stitched to the wire frame, and can be slipped off and on. It is held in position and sealed at the edges against leakage of dirty air by a spreader grid, which draws the individual pockets of the felt gloves tautly over the wire frame. They can be cleaned when necessary without removal from the panels or interference with the operation of the air-conditioning system by means of a small specially-designed vacuum cleaner, furnished with each installation. The cleaner weighs 5 lb.

A feature of this filter, according to the manufacturer,



is that its resistance is little affected by a damp or oily atmosphere. In the illustration, the top view is the intake side and the bottom, the clean air side.

Cools Railway Cars

AN AIR conditioner for railway cars upon which development work has recently been completed cools, dehumidifies and washes air during the summer and washes and humidifies it in the heating season. The device consists of an ice storage chamber and an overhead chamber containing the blowers, washing and cooling units. Three motors of ⅓, ¼ and 1/6 hp. constitute the electrical load; two of the motors operate intermittently.

After the bunker is iced, pressing two push buttons inside the car puts the unit in operation. A reserve of water in the ice bunker is picked up by a pump and forced to the overhead chamber. Part of the water goes to the spray jets and the remainder passes through finned tubing to assist in dehumidification. Water is then returned to the ice chamber where it trickles over the blocks of ice and returns to the reservoir. Air circulation is maintained by two blowers mounted on opposite ends of one motor; air is blown through a duct placed inside or outside the car along the decks, and is recirculated. Outside air is filtered. The illustration shows the ice chamber in place in a car.

In a ten-hour test of the equipment reported by the American Car and Foundry Company, 30 Church st., New York City—the manufacturer—the power requirement for the three motors was found to be 4400 watts (440 watts per hour). On the dining car tested, four fans at 60 watts each were discarded, giving an additional load for the air-conditioning equipment of 200 watts.

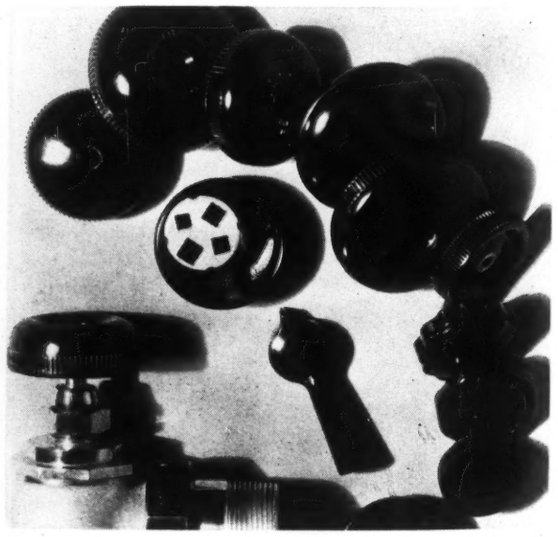
Heating Field Uses Molded Knobs

A GOOD idea of how phenolic plastics are used in the heating field is given in the accompanying illustration. All of the knobs are molded of one of the newer synthetic plastic materials made by General Plastics, Inc., North Tonawanda, N. Y.

The physical properties of this material are:

Tensile strength	6,500 lb. per sq. in.
Compressive strength	32,000 " " " "
Transverse strength	11,500 " " " "
Dielectric strength	300 to 500 volts per mil.
Co-efficient of expansion	0.00003 in. per in. per degree C.
Specific gravity	1.33
Weight per cubic inch	0.78 oz.

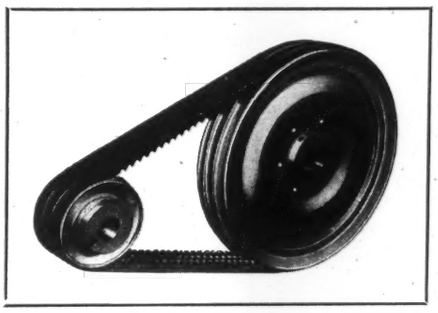
Water absorption—48 hours immersion in boiling water 0.8 Special water resisting stock Hot Water absorption for 8 days 0.55% shrinkage 0.0038 in. per in.



V-Groove Steel Pulleys

THE Dayton Rubber Manufacturing Co. of Dayton, Ohio, announces a new line of single and multiple V-groove pulleys for use with their V-belt drives for ratings of 7½ hp. and below.

These new pulleys are light in weight, making them suitable for machines requiring smaller horsepowers. They are formed from heavy gage pressed steel, are welded both at the rim and at the web, and are assembled with a hub of special construction to promote accurate balance and true running. An aluminum finish adds to the appearance of the product.



For Pressure Relief

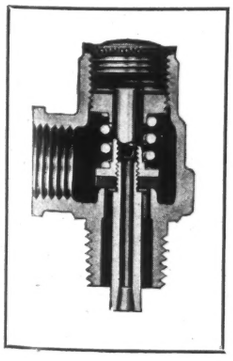
PLACED on the market a few weeks ago to meet demand for a small relief valve for use on water pumps, water heaters, and wherever water, oil, or air pressures up to 125 lb. are to be relieved, poppet-type relief valves of the Watts Regulator Co., Lawrence, Mass., are made for pressure relief only, and for pressure and temperature relief.

The valve is entirely of bronze and equipped with ½-in. male inlet so that it can readily be installed in a fitting or in a small space. The relief opening is full half inch. It is made only with ½" I. P. S. male inlet, ½" I. P. S. female drain.

The disc is of inert composition, impregnated to prevent seizing. The spring is phosphor bronze, and the slotted adjustment is protected by a screwed brass seal cap. There are no loose parts.

Stock valves are set at the factory at 125 lb. and are adjustable from 30 to 175 lb.

Operation of the pressure-relief type is as follows: Pressure in the system or vessel presses against the valve disc which is held to its seat by the adjusting spring. When the pressure becomes sufficient to lift the disc against the spring, it lifts the disc off the seat, allowing fluid to run to waste until the pressure is reduced. The spring then returns the disc to its seat, shutting off the flow.



The pressure relief feature of the pressure-and-temperature relief type is the same and in addition this valve relieves excessive temperatures. The temperature relief element consists of a fusible plug which will melt at between 220 and 230 F. This plug is mounted in the end of a hollow brass tube which extends well into the water in the fitting or tank. When the temperature melts the fusible plug, it allows the fluid to run up through the tube and out the relief opening to waste.

This valve must be installed either directly on the tank or in the hot water line as close to the tank as possible.

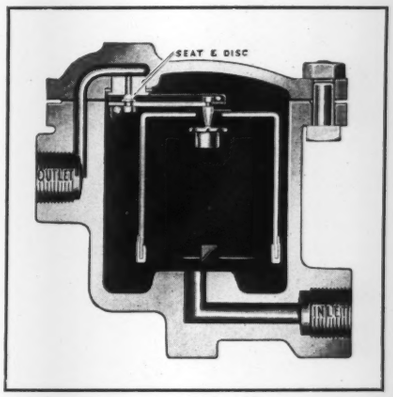
If desired the valves can be furnished with a test lever handle for periodic testing.

Tapered Spindle in Trap

TWO new inverted bucket traps, recently introduced, embody several improvements in design and materials. Both use an anti-balancing device, consisting of a valve arrangement which replaces the air vent hole in the bucket.

In one trap, the bucket is suspended on a tapered spindle and the clearance between this spindle and the hole in the stainless plate on the bucket serves as the air vent. While the bucket is floating or in a filling position, the clearance is small, but as the bucket starts to sink, this clearance increases. The bucket moving up and down the tapered spindle prevents the air vent from becoming clogged with sediment or oil, according to the manufacturers, The Strong, Carlisle & Hammond Co., Cleveland, Ohio.

The discs and seats are made from special alloy and the lever, pins and wear plate on the bucket are all made from a "work-hardening" steel.



To Filter Air

TWO new filters designed especially for warm air heating systems, air-conditioning units, room coolers, unit ventilators, and warm-air heating systems have recently been introduced. The filtering medium in both types consists of fabricated split wire woven into pads of the proper size and thickness.

In one of the filters the pad is contained in a cardboard casing, making it practical to throw away or destroy the entire filter when it has accumulated a sufficient quantity of dust to restrict the air flow, and replace it with a complete new unit. The other filter is semi-permanent, since the renewable filter pad is contained in a metal casing having expanded metal covers. The filter pad is renewed by removing two screws and lifting the cover from the casing.

The filters are made in two standard sizes—20x20 and 16x25—but can be furnished on quantity orders